

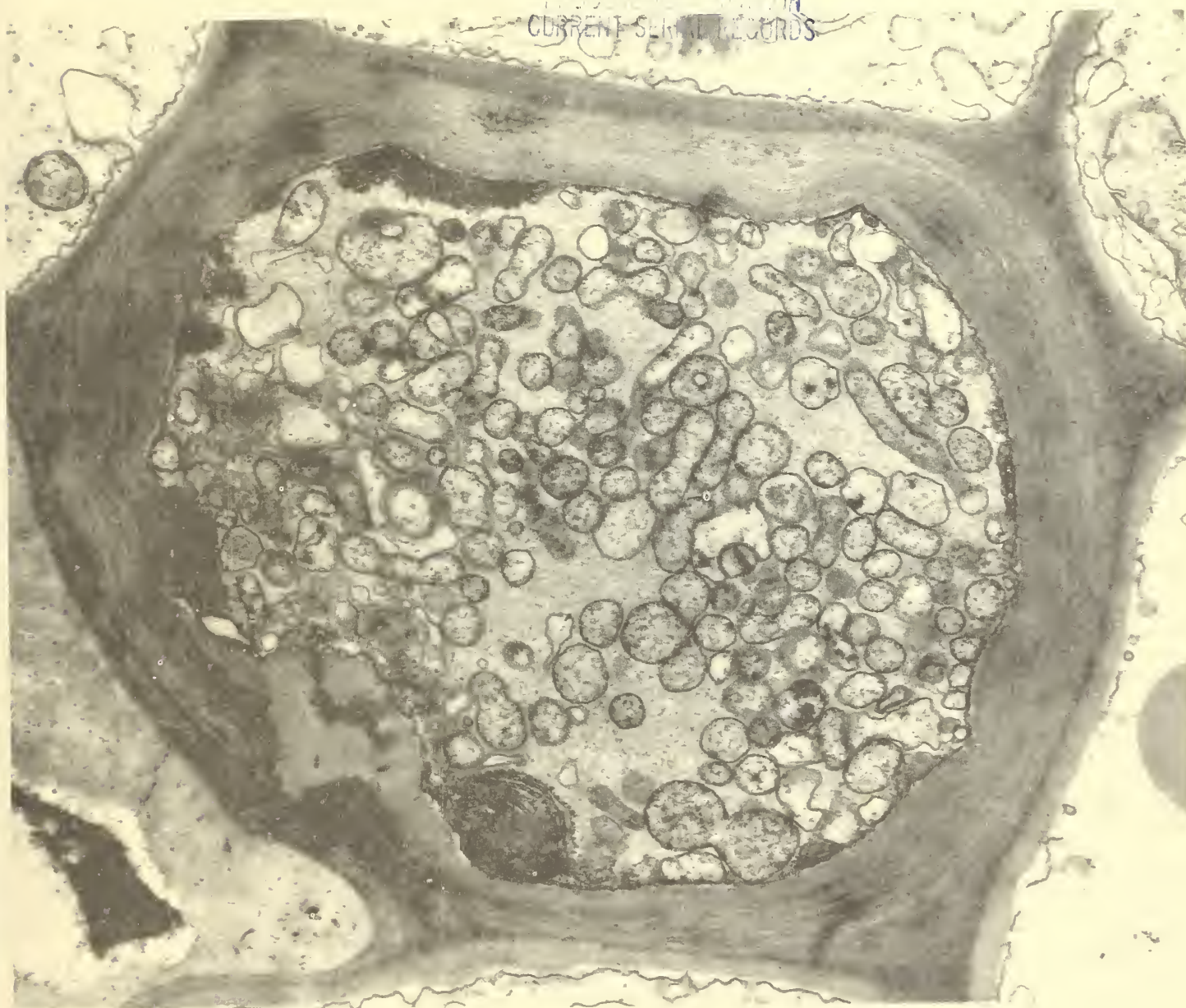
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Held in
COACHELLA VALLEY, CALIFORNIA

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ROY W. NIXON

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Perhaps no individual has been more closely identified with the California Date Industry than Roy W. Nixon. From his arrival in the Coachella Valley in 1923 until his death in 1976, his professional life centered around date palms.

His bulletin "Date Growing in the United States" has been in general use in all of the date growing areas of the world. Its revision to reflect currently practiced cultural operations was his major task during his last year of activity.

In his early years at the U. S. Date and Citrus Station, one of Roy's most interesting assignments was the identification of date varieties, in which he cooperated with W. T. Swingle, S. C. Mason and others. Later, one of his important activities was date breeding in collaboration with J. R. Furr.

At one time students from foreign countries were accommodated at the Station and much of their instruction was the responsibility of Roy Nixon. Extensive visits to Iraq, Saudi Arabia, Egypt, Sudan, Tunisia, Algeria, Morocco, Spain and Mexico were made. Friendly, cooperative relationships were established with date growers, scientists and government officials of those countries.

Roy collected most of the available publications and literature citations on date culture up to 1965, and conserved the collections of his predecessors at the Station. As a result, the U. S. Date and Citrus Station probably has the world's finest single collection of date literature.

One of Roy's foreign contacts expressed the sentiment of a vast number of his friends in a letter that I received recently and from which I quote: "I am deeply sorry to read about the late Mr. Roy Nixon, who was the greatest date scientist and a foremost honest human being."

A remarkable and well deserved tribute!

LETHAL YELLOWING: A POTENTIAL DANGER TO DATE PRODUCTION

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ABSTRACT

Lethal yellowing is a fast spreading, destructive disease of coconut palm that is believed to affect a number of other palm species including *Phoenix dactylifera*. This disease is present in Florida, the West Indies and possibly the west coast of Africa. Symptoms include fruit loss and inflorescence necrosis, followed by death of the entire crown within 3 to 6 months. Observation of the phloem of declining palms by electron microscopy reveals the presence of mycoplasma-like organisms. These organisms are presumably transmitted from tree-to-tree by a piercing-sucking insect, probably a leafhopper. However, a vector has not yet been found. Suggested control measures include quarantine of the infested areas, removal of diseased palms, planting of resistant varieties, and treatment with tetracycline antibiotics.

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Lethal yellowing (LY) is a devastating disease of coconut palm (*Cocos nucifera* L.), that was first reported on the Caribbean island of Jamaica at about the turn of the century (2). LY has decimated coconut production in Jamaica (Fig. 1) and has spread to Hispaniola, Cuba, Nassau and other islands of the West Indies. The disease was found in Key West, Florida in 1955 where 15,000 coconut palms were killed over a 7 year period. LY appeared in Miami, Florida in 1971 and has killed more than 80% of the 350,000 coconut palms in the greater Miami area in the succeeding 4.5 years (8).

The Kaincope disease of coconut palm in Togo, West Africa is identical to LY in symptomology and therapeutic response. It is likely that this disease and LY are coincidental (8, 12). If so, the distribution and worldwide significance of LY are greatly extended.

When LY became established on the Florida mainland, a new phenomenon of paramount importance was observed. Several other species of palms were noted to be declining and dying in areas where LY was actively spreading in coconut palms (13, 14). The suspected causal agent of LY was also observed in these declining species. The suspected host list has been expanded (Table 1) and now includes the date palm, *Phoenix dactylifera* L. (Fig. 2), as well as *P. canariensis* Hort. ex Chab. (Fig 3), and *P. reclinata* Jacq. (10, 18).

SYMPTOMOLOGY

The symptoms of LY in coconut, as the name implies, consist of a rapid, generalized chlorosis followed by death of the palm, usually within a 4 month period. Prior to the development of yellowing symptoms, developing fruit drops from the tree and new inflorescences become necrotic, even before the opening of the spathe. Most of the fallen fruit have a grey to black, water-soaked discoloration at the stem end. Yellowing begins at the tips of the fronds and moves toward the frond bases. The older fronds within the crown are the first to become yellow. The yellowing extends upwards through the crown from old to young fronds. In the dates and some other species of palm, the fronds do not become yellow, but rather become desiccated and gray-brown, the older fronds again being affected first. Fruit loss and inflorescence necrosis also occur in date palms.

When approximately half of the crown has become yellowed or necrotic, the folded spear or bud leaf will often become necrotic. A soft rot then extends down the spear and into the bud shaft, eventually reducing the meristematic area to a putrid, slimy mass. Death of the rest of the crown follows rapidly. The crown soon topples from the stem, leaving a naked trunk.

ETIOLOGY

A common factor observed in all declining palm species listed in Table 1, along with similar symptom expression, is the presence of mycoplasma-like organisms (MLO) within the sieve tubes of the affected trees (Fig. 4). The MLO, which are present only in the phloem tissues of the diseased palms, are the suspected causal agents. Mycoplasmas are the smallest of all known cellular organisms. They are simpler than bacteria, have no cell wall, and have only a delicate membrane surrounding their cytoplasm. Currently, mycoplasmas or mycoplasma-like organisms are known to cause, or to be associated with more than 100 plant diseases. The term mycoplasma-like is used when these organisms have been observed by electron microscopy, but have not been isolated and grown in pure culture. Attempts to isolate the LY organism are underway in both Florida and Jamaica.

MODE OF SPREAD

The mechanism of spread of LY has not been determined, although it is the belief of many researchers that the LY pathogen has been transported around the West Indies and Florida by wind-borne arthropod vectors. The only known means of natural transmission of MLO's in other plants has been by leafhoppers and

psyllids. This is a plausible method since these insects feed by piercing the phloem cells of plants and sucking out the sieve tube sap. If the plant on which the insects are feeding is infected by an MLO, the insects will pick up the organisms and become infected themselves. The MLO's are later transmitted to the sieve tubes of other plants when the insects feed on them.

Extensive transmission experiments have been carried out in Jamaica with white flies, flatid and fulgorid plant-hoppers, tingid bugs, and gall mites (1, 3, 5). Other tests with the planthoppers *Haplaxius crudus* (Van Duzee), *Antillixius* spp., two species of *Omolocna*, *Colpoptera elevans* (Walker), *Psenoflata brevis* (Van Duzee), and *Ceratophis variabilis* (Hille Ris Lambers) were made in Jamaica (16). No specific transmissions of LY have been reported.

Rotary flight nets within palm plantings and sticky traps within palm crowns have been employed to study the insect fauna present in coconut palms in South Florida. Emphasis was placed on sampling the homopteran insects belonging to the Suborder Auchenorrhyncha. From this survey, the following planthoppers and leafhoppers have been selected as the primary suspect vectors to be used in transmission attempts: *Haplaxius crudus* (Van Duzee), *Chlorotettix* spp., *Balclutha* spp., *Graminella* spp., *Empoasca* spp., *Delphacodes* spp., *Agallia constricta* (Van Duzee), *Idioderma virescens* (Van Duzee), *Pintalia* spp., *Bothriocerna* spp., *Protalebrella brasiliensis* (Baker), *Planicephalus flavicosta* (Stal).

CONTROL

Attempts to contain or slow the spread of LY in Florida have been based on an integrated program involving removal of diseased palms in areas where the disease is advancing; protection of healthy palms and therapeutic treatment of diseased palms with the antibiotic, oxytetracycline-HCl; quarantine of all affected counties; and replanting with non-susceptible types of palms (10). Vector control is another possible avenue for LY control; however, no feasible control may be aimed at the vector until the target insect is known.

The removal of diseased palms was the

first line of defense against LY in Florida until development of the antibiotic treatment. Some twelve thousand diseased palms were removed early in the epidemic in Florida in an effort to slow the spread of disease by the reduction of inoculum (10). Cutting diseased palms did not stop the spread of LY in either Florida (8) or Jamaica (15). However, although no quantitative measurements were recorded it is certain that the cutting program did retard the spread of LY somewhat.

Treatment of palms with oxytetracycline is a recently approved control measure that is presently available for both coconut and pritchardia palms in Florida (6). This treatment is used both therapeutically in diseased palms prior to the development of extensive symptoms (7), and as a protectant for healthy palms (9). It is generally established fact that mycoplasmas are sensitive to this type of antibiotic (17). A Florida Department of Agriculture and Consumer Services Program of treating healthy palms surrounding new cases of disease in areas of low LY incidence has effectively depressed disease spread for 16 months in five counties. A test to determine the protective action of oxytetracycline in the Canary Island date palm is currently underway. No data are available on the efficacy of antibiotic treatment in *Phoenix dactylifera*.

To curb the inadvertent spread of LY by man, the State of Florida has implemented a quarantine on all infested counties to stop the shipment of susceptible palms out of the affected areas. In addition, Texas, Hawaii, California and Louisiana have all enacted quarantines against the shipment of susceptible palm species from Florida into their states. The spread of LY in nature is extremely fast, so particular precautions should be taken to prevent the movement of affected trees to areas free of LY.

The major factor for LY control in coconut is the planting of the resistant 'Malayan Dwarf' cultivar. The Malayan Dwarf coconut palm is highly resistant to LY and is being widely planted in both Jamaica and Florida (4, 11). Hybrids between Malayan Dwarf and other coconut cultivars also have a high degree of resistance to LY (4). The degree of susceptibility of resistance of various date cultivars to this disease is unknown.

DISCUSSION

The current state of knowledge about lethal yellowing in coconut palm is very sketchy, and much less is known about the lethal declines of date and other palms that are associated with lethal yellowing. In all cases, the disease acts rapidly, killing the affected palm in about 4 months. Tree-to-tree spread is rapid and nearly always affects 100% of the susceptible palms in any infested area. Symptom development is similar in all species and all affected palms have mycoplasma-like organisms present in their sieve tubes. In addition, six species tested have all responded to oxytetracycline treatment. The evidence thus far accumulated indicates that lethal yellowing attacks not only coconut palm, but also the other species listed in Table 1. The causal agent is believed to be a mycoplasma, but this has not been proved. The organism must be isolated in pure culture and then used to reproduce the disease after inoculation in order to prove pathogenicity.

The chances of lethal yellowing spreading from Florida to the Southwestern USA have been lessened considerably by instituting a quarantine on Florida palms. The potential danger of LY to date production in Africa is real if the Kaincope disease proves to be coincidental with LY. A priority research effort should be made to determine if Kaincope is identical to LY and whether or not it can attack date palms.

Judging from experience with other diseases of mycoplasma-like etiology, the vector is probably a piercing-sucking insect such as a leafhopper. However, the vector of lethal yellowing is, as yet, unknown. Since the vector of LY is probably a flying insect, it would also be important to determine the identity of insects on date palm that could be potential vectors, especially members of the Cicadellidae. If LY were to appear in a date production area, a control program might be instituted against these insects. The infected trees should be removed and the feasibility should be explored of antibiotic treatment of palms in a 100 yard circle around the infection site, as successfully used in Florida.

Another priority area of research would be the screening of various date cultivars

for resistance to LY. This would have to be done in an LY infested area, but could be of inestimable value to future date production. LY resistance has been found in the coconut palm and is being fully exploited in both Florida and Jamaica.

LITERATURE CITED

1. Carter, W., R. K. Latta and J. R. Suah. 1965. The symptoms of lethal yellowing disease of coconut palms. *FAO Plant Protect. Bull.* 13:49-55.
2. Fawcett, W. 1891. Report on the coconut disease at Montego Bay. *Bull. Bot. Dep. Jamaica* 23:2.
3. Grylls, N. E., and P. Hunt. 1971. Studies on the etiology of coconut and lethal yellowing in Jamaica, by mechanical and bacterial inoculations and by insect vectors. *Oleagineux* 26:543-549.
4. Harries, H. C. 1972. Botany/plant breeding, p. 15-30. *In* 12th Rep. of Res. Dep., Coconut Industry Board, Jamaica. 65p.
5. Heinze, K. 1972. Lethal yellowing disease of coconut. *FAO Report TA 3152* to the Government of Jamaica.
6. McCoy, R. E. 1974. How to treat your palm with antibiotic. *Univ. Fla. Agric. Exp. Sta. Cir. S-228*. 7p.
7. McCoy, R. E. 1975. Effect of oxy-tetracycline dose and state of disease development on remission of lethal yellowing in coconut palm. *Plant Dis. Rep.* 59:717-720.
8. McCoy, R. E. 1976. Comparative epidemiology of the lethal yellowing, Kaincope and cadang-cadang diseases of coconut palm. *Plant Dis. Rep.* 60:498-502.
9. McCoy, R. E., V. J. Carroll, C. P. Poucher, and G. H. Gwin. 1976. Field control of coconut lethal yellowing with oxytetracycline-hydrochloride. *Phytopathology* 66: 1148-1150.
10. McCoy, R. E., D. L. Thomas, and J. K. Condo. 1976. Lethal yellowing—why the quarantine. *Fla. Nurseryman* 21(3):49-52.
11. Midcap, J. T., and R. E. McCoy. 1975. Malayan Dwarf palm, resistant to lethal yellowing, is recommended for planting in Florida. *Sunshine State Agric. Res. Rep.* 20(3):8-9.
12. Ollagnier, M., and G. Weststeijn. 1961. Coconut diseases in the islands of the Caribbean: comparison with the Kaincope disease in Togo. *Oleagineux* 16:729-736.
13. Parthasarathy, M. V. 1973. Mycoplasmalike organisms in the phloem of palms in Florida affected by lethal yellowing. *Plant Dis. Rep.* 57:861-862.
14. Parthasarathy, M. V. 1974. Mycoplasmalike organisms associated with lethal yellowing disease of palms. *Phytopathology* 64:667-674.
15. Romney, D. H. 1971. Attempts to control lethal yellowing, p. 85-86. *In* 11th Rep. Res. Dep., Coconut Industry Board. Jamaica. 90p.
16. Schuiling, M., and C. G. Johnson. 1973. Current attempts to find a vector associated with lethal yellowing disease of coconut. *Principes* 17:151-159.
17. Smith, P.F. 1971. The biology of mycoplasmas. Academic Press, New York. 257p.
18. Thomas, D. L. 1974. Possible link between declining palm species and lethal yellowing of coconut palms. *Proc. Fla. State Hort. Soc.* 87:502-504.

Table 1. List of declining palms in South Florida infected with mycoplasmalike organisms and placed under the lethal yellowing quarantine

Scientific Name	Common Name
1. <u>Cocos nucifera</u> L.	Coconut - all varieties including Malayan Dwarf
2. <u>Veitchia merrillii</u> (Becc.) H.E. Moore	Adonidia or Christmas palm
3. <u>Pritchardia pacifica</u> Seem. & H. Wendl.	Fiji fan palm
4. <u>Pritchardia thurstonii</u> F. Muell. & Drude	
5. <u>Arikuryroba schizophylla</u> (Mart.) Bailey	Arikury palm
6. <u>Corypha</u> spp.	Talipot palm
7. <u>Phoenix reclinata</u> Jacq.	Senegal date palm
8. <u>Phoenix canariensis</u> Hort. ex Chab.	Canary Island date palm
9. <u>Phoenix dactylifera</u> L.	Date palm
10. <u>Trachycarpus fortunei</u> (Hook.) Wendl.	Windmill palm
11. <u>Mascarena verschaffeltii</u> (Wendl.) Bailey	Spindle palm
12. <u>Caryota mitis</u> Lour.	Cluster fish-tail palm
13. <u>Borassus flabellifer</u> L.	Palmyra palm
14. <u>Chrysalidocarpus cabadae</u> H.E. Moore	Cabada palm
15. <u>Dictyosperma album</u> (Bory) H. Wendl. & Drude	Hurricane or Princess palm
16. <u>Latania</u> spp.	
17. <u>Arenga engleri</u> Becc.	



Figure 1. Coconut plantation destroyed by lethal yellowing in Jamaica.



Figure 2. Lethal decline of *Phoenix dactylifera* in Florida. This disease is believed to be caused by the lethal yellowing pathogen.



Figure 3. *Phoenix canariensis* affected by lethal decline (left), healthy (right), in Florida.

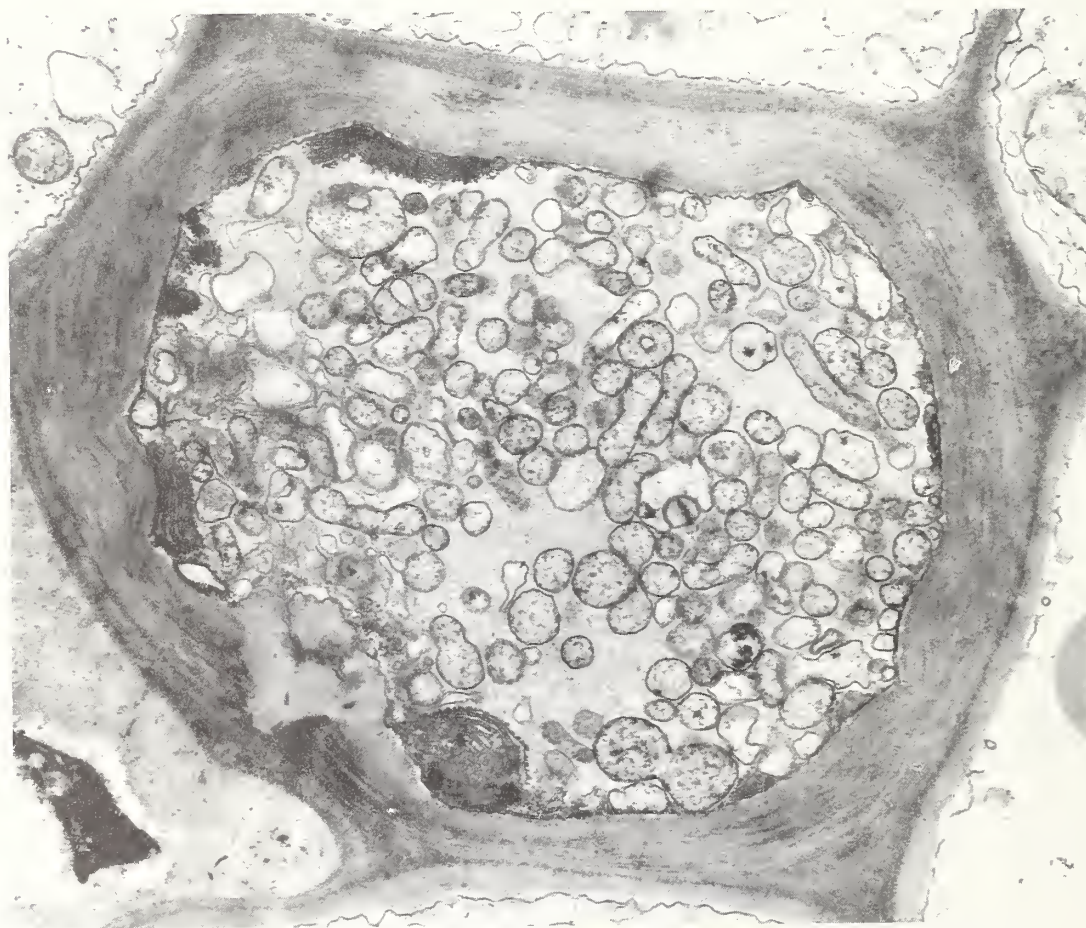


Figure 4. *Mycoplasma*-like organisms within a phloem sieve tube in a declining *Phoenix* palm.

CHANGES IN QUALITY OF FIELD RUN DATES UNDER VARIOUS COMBINATIONS OF OUTDOOR AND REFRIGERATED STORAGE¹

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ABSTRACT

Early-, mid-, and late-season Deglet Noor dates were stored 0-5 mo outdoors then moved to cold storage for 7-12 mo to determine optimum storage conditions for dates. After 5 mo outdoors and 7 mo in cold storage, 57% of early-season, 64% of mid-season, and 25% of late-season dates were marketable as fresh fruit. We concluded from visual observations that outdoor storage of dates should be kept to a minimum if optimum color and quality are to be maintained. Soluble pigment content of dates increased in all treatments and the rate of increase generally progressed with storage time outdoors. Changes were not consistent in moisture content or shear-force measurements. Sucrose inverted to fructose and glucose only in dates held outdoors 5 mo.

Three storage grades of mid-season Deglet Noor dates were stored 12 mo at -3, 2, and 4° C. in conventional open and polyethylene-lined bins. We concluded from visual observations of the dates that storage in lined bins was beneficial to dry grades, but not to moist grades of dates. Soluble pigment content increased in the dates in all storage treatments. Differences were not significant between dates in lined and unlined bins for either sugar or shear-force measurements.

Date Growers' Inst. Rep. 53:9

The effects of storage conditions on quality of 'Deglet Noor' dates were studied in two 12-mo tests to help define optimum storage conditions. Changes in quality of dates during storage were reviewed by Rygg (4). Because of mechanical harvesting and fewer picks per season, more dates of different stages of maturity and dryness reach the packing-house today than previously.

The first test was a study of changes in date quality of 54 bins of ungraded early-, mid-, and late-season harvested dates under actual commercial conditions of refrigerated storage and a combination of outdoor and refrigerated storage. Each bin contained about 450 kg of dates. The second test was designed to compare the quality of 18 bins of three storage grades of dates (waxy, No. 1 dry, and No. 2 dry) refrigerated in polyethylene-lined and conventional unlined bins. We now report the changes found in USDA grades, texture, and in moisture, pigment, and sugar content during the tests.

MATERIALS AND METHODS

All procedures and methods of analyses were described in a preliminary report (3).

Statistical analyses — A computer program for multiple regression analysis was used. The independent variable (X) was the number of months since harvest and the dependent variable (Y) was either grade, texture, moisture, pigment, or sugar content. For each Y variable, the computer selected a best fit equation by use of one or all of the X variables from the equation $Y = a + bX + cX^2 + dX^3$. A significant F value was used to determine whether to enter each X variable into the

equation.

In certain cases the data indicated no differences between storage temperature, storage grade, nor early-, mid-, and late-season dates. Covariance analyses were run to determine whether there were significant differences between the slopes of the lines or the adjusted means. If there were no differences, the groups were combined and statistically considered to be from a single population. A new equation was then generated for the combined data.

RESULTS AND DISCUSSION

STORAGE TEST No.1

Of 18 bins each of ungraded early-, mid-, and late-season Deglet Noor dates, 3 bins were held outdoors for each time (0-5 mo); one bin from each time outdoors was moved to cold storage at -3, 2, and 4° C. Total number of bins was 54. Total time of storage (six combinations of outdoor plus cold storage) was 12 mo. Each harvest was from a different garden. Hereafter, only the months of storage outdoors will be referred to; i. e., dates held outdoors 0, 1, 2, 3, 4, and 5 mo were in cold storage 12, 11, 10, 9, 8 and 7 mo, respectively, to complete the 12-mo storage period.

Grading — In commercial practice, dates are sampled and graded at harvest by USDA graders to determine the price to be paid to the grower. For this test, USDA graders graded samples from each bin each month. At harvest, early- and mid-season dates were mostly No. 1 and No. 2 dry grades (Fig. 1), and average moisture contents of early- and mid-season dates were 15.2 and 14.3% respectively. Late-season fruit were mostly

¹ Mention of a proprietary product in this paper does not constitute a recommendation or an endorsement of the product by the U. S. Department of Agriculture.

natural, waxy, and No. 1 dry grades at harvest; average moisture content was 17.8%. Part of the diversity of grades among harvests was attributed to variability in quality and in production of each garden. After 0 mo outdoors (12 mo in cold storage), early- and mid-season dates increased in No. 1 dry; late-season dates increased in natural and waxy grades. After 5 mo outdoors, early-season dates were slightly higher, and mid-season dates slightly lower, in No. 1 dry grades than dates held outdoors 0 mo; late-season dates were slightly higher in natural and lower in waxy grades than dates held outdoors 0 mo. In dates from all harvests, green and moist fruit were converted to other grades and the per cent of culls decreased slightly during storage. We had expected that grading would show a decrease in quality of dates during storage, but it did not. Uniformity of color within each lot was noted during grading, but browning associated with deterioration during storage was not a part of this grading.

At the end of the test all bins of dates (each bin contained 270-320 kg of dates) were graded in the packinghouse. This grading differed from the USDA grading in that the dates were divided according to potential use in marketing; grading is biased by the particular packinghouse and its marketing procedures. Grades and potential markets are as follows:

Waxy fruit — waxy appearance, clear or almost transparent and have a soft wrinkle; are generally hydrated and used as whole fruit for the domestic market.

High No. 1 dry fruit — a harder wrinkle, less transparent, less waxy in appearance, and generally smaller than waxy grades; are hydrated and pitted for the domestic market.

Low No. 1 dry fruit — opaque, dull in appearance, usually have dry stem ends, and usually smaller than high No. 1 dry grade; are hydrated and used for the whole fruit export market.

Product fruit — very dry, small, and have a lower ratio of tissue to pit than the other grades; cannot be hydrated into a marketable date and are dried further and used for dry byproducts such as granules for cake and cookie mixes.

Cull fruit — are used to make edible date syrup or occasionally used for livestock feed.

After 12 mo, 51-62% of early-season dates were marketable as whole fruit and 34-45% as products (Table 1). In mid-season dates, 84-87% were marketable as whole fruit after 0-2 mo, and 64-87% after 3-5 mo. In late-season dates, 85-89% were marketable as whole fruit after 0-1 mo, 53% after 2 mo, and 5-29% after 3-5 mo outdoors. This grading at the packinghouse reflected, better than the USDA grading, the deterioration that took place during storage.

Moisture content — Moisture content apparently increased during the first 5 mo (3), but this trend did not continue for all treatments. Moisture content increased in dates held 0 and 5 mo, decreased in those held 4 mo, and decreased and then increased, in those held 2 and 3 mo outdoors. Moisture content for all grades and harvests of dates did not differ significantly and data were combined; trends could not be established.

Monthly moisture contents of dates in three bins held in cold storage 12 mo varied as much as 4-5 percentage points. This variation was attributed to sampling (2). At first all the bins were sampled with a standard bin sampler. After 5 mo, all the bins were sampled by hand, either because the partially empty bins did not dump in the bin sampler or the dates became too sticky to fall freely from the bins. It was difficult to obtain by hand representative samples from the bins.

Pigment content — The amount of soluble pigment in dates indicates the relative darkening associated with storage even though it is not directly related to visual evaluation of darkness in dates. All grades of dates from all harvests had increased in pigment content during the first 5 mo (3) and this trend continued. Differences were not significant among groups and data were combined for all grades of dates and for the three cold storage temperatures. Soluble pigment contents increased 1.5, 2, and 4 mg/g in early-season dates (Fig. 2); 1.5, 2, and 5 mg/g in mid-season dates (Fig. 3); and 2, 4, and 7 mg/g in late-season dates (Fig 4) during storage outdoors 0, 3, and 5 mo, respectively. After 12-mo, soluble pigment content was higher in late- than early- and mid-season dates.

Sugar content — At harvest, early-, mid- and late-season dates contained 56-58, 54-58, and 59-62% sucrose on a dry wt basis. Little change in sucrose content was apparent after 5 mo (3). This trend continued for all treatments except for dates held outdoors 5 mo in which 20% of the sucrose inverted (Fig. 5) to fructose and glucose (Fig. 6). Data did not differ significantly among grades of dates and temperatures, and were combined. The ratios of sucrose to fructose and glucose in fruit stored outdoors 0, 1, 2, 3, 4, and 5 mo were 2.7, 2.6, 2.3, 2.7, 2.1, and 1.4, respectively, after 12 mo. Crystalline sucrose in date tissue, known as "sugar-wall," sometimes forms during storage. Except for the dates (5 mo) that inverted during storage, all were prone to "sugar-wall" since these ratios are 2.1 or greater (1, 5). In dates that had been outdoors 4 mo or more, sugar wall began to appear after 5 and 10 mo in late- and mid-season fruit, respectively.

Textural changes — Shear force values (kg/date) appeared to decrease during the first months of storage (3) and remained nearly constant for the rest of the storage test, regardless of treatment. Shear force values at 1, 2, and 12 mo were 19, 13, and 12 for early-season dates; 15, 12, and 11 for mid-season dates; and 14, 11, and 10 kg/date for late-season dates, respectively.

Visual observations — The dates, particularly late-season, darkened progressively as storage time outdoors lengthened. Late-season dates held outdoors 5 mo were a very dark red-brown. Natural dates were darker than waxy, waxy darker than No. 1 dry, and No. 1 dry darker than N. 2 dry.

Early-season dates remained dry and loose during the storage test, mid-season dates became somewhat sticky, and late-season dates became very sticky and difficult to sample. We concluded from visual observations of all the treatments that if the optimum color of dates, particularly of moist dates, is to be maintained, fruit should not be stored outdoors more than 1 mo.

STORAGE TEST NO. 2

Of 6 bins each of three storage grades of mid-season Deglet Noor dates, 1 polyethylene-lined and 1 conventional unlined bin were stored at -3, 2, and

4° C. Total number of bins was 18. Total time of storage was 12 mo. The three storage grades, waxy, No 1 dry, and No 2 dry, are hereafter called grades A, B, and C, respectively.

USDA grading — After 5 mo, consistent trends in grade content were not apparent (3). Grades did not differ significantly for dates at the three temperatures so data were combined (Fig. 7). During storage, grade A, mostly natural and waxy fruit at harvest, increased in No. 1 dry fruit; grade B, mostly No 1 dry fruit at harvest, increased in waxy fruit; grade C, mostly No. 1 dry fruit at harvest, increased in No. 1 dry fruit. After storage, unlined bins contained less natural and waxy fruit and more No. 1 dry fruit than lined bins.

Moisture content — During storage, moisture content of dates decreased in all three grades in lined and unlined bins (Fig. 8). Slight and inconsistent changes were reported earlier (3). According to analysis of covariance, moisture content of waxy fruit from grade A was significantly higher when stored in unlined than in lined bins. Moisture content did not differ between lined and unlined bins of grade B and C, and the data were combined.

Pigment content — Soluble pigment content had increased during the first 4 mo of storage (3) and continued to increase in dates of all three grades stored in both lined and unlined bins (Fig 9). According to analysis of covariance, No. 1 dry dates of grade B were significantly higher in soluble pigment content when stored in unlined than in lined bins. Soluble pigment content did not differ significantly for dates of grades A and C stored in lined and unlined bins, and the data were combined. Soluble pigment content increased in No. 2 dry fruit of grade C more than in the other fruit. Pigment content of dates increased 2-3 mg/g in test 2 and 1.5-2 mg/g in test 1.

Sugar content — The sugar content of dates during the first 4 mo changed little (3) and this trend continued, except for grade A. In the natural and waxy dates in Grade A, some sucrose (6-10%) inverted, during storage, to fructose and glucose. Before and after storage No. 1 and No. 2 dry dates were lower in fructose and glucose and higher in sucrose than the natural and waxy fruit (Table 2.) Sugar

contents of dates in lined and unlined bins did not differ significantly and the data were combined.

Textural quality — Consistent trends could not be determined after 5 mo when the progress report was made (3). Peak shear forces (kg/date) were: for waxy dates of grade A, 7 at harvest and 11 and 9 after storage in unlined and lined bins, respectively; for No. 1 dry dates of grade B, 8 at harvest and 9 after storage in unlined and lined bins; for No. 1 dry and No. 2 dry dates of grade C, 10 and 13 after storage in unlined and lined bins, respectively. Shear force showed neither changes in textural quality of dates during storage nor consistent differences between dates in unlined and lined bins.

Visual observations — Most of the dates became sticky and stuck together during storage. Dates in lined bins were generally stickier than those in unlined bins. The dates in the lined bin of grade A held at 4° C. were particularly sticky.

Grade A fruit held at -3° C. were visibly darker in unlined than in the lined bin. For grade A dates held at 4° C., color was lightest in the unlined bin. For grade B dates, color was slightly lighter in unlined than in lined bins, except for dates held at 4° C.

We concluded from visual observations of all the treated dates that, under our conditions, lined bins were beneficial for dry grades of dates and detrimental to moist grades of dates. Dates might not have become sticky if they had not been washed when graded for storage.

SUMMARY

In test 1, 54 bins of early-, mid-, and late-season Deglet Noor dates were stored outdoors, then moved to cold storage. According to USDA grading, early- and mid-season dates increased in No. 1 dry grade fruit during the 12 mo storage and late-season dates increased in natural and waxy grade fruit. At the end of the test, 51-62% of the early-season dates were marketable as whole fruit, regardless of storage treatment. After 0-2 mo storage outdoors, 84-87% of mid-season dates were marketable as whole fruit; continued storage outdoors for 3-5 mo decreased marketable whole fruit to 64-

78%. When held outdoors 1 mo and 11 mo in cold storage, or in cold storage 12 mo, 85-89% of late-season dates were marketable as whole fruit; continued storage outdoors decreased marketable whole fruit to as low as 5%.

Consistent trends in moisture content were not established when dates were held either for 12 mo in cold storage or up to 5 mo outdoors followed by cold storage. Shear force values decreased slightly during the first 2 mo of storage and remained nearly constant for the rest of the test, regardless of treatment. Sugar content remained fairly constant in all treatments except those held outdoors 5 mo in which 20% of the sucrose inverted to fructose and glucose.

Soluble pigment content, the main chemical measurement that showed deterioration of dates with storage, increased in all treatments, including cold storage, and the rate of change generally increased progressively with storage time outdoors. We concluded from the tests and visual observations of all treatments, that outdoor storage of dates should be kept to a minimum if optimum color and quality are to be maintained. None of our chemical tests indicated the extent of deterioration in dates that was observed visually. New, sensitive tests are needed to measure quality changes in dates during storage.

In test 2, 18 bins, containing three storage grades of mid-season Deglet Noor dates in conventional open and in polyethylene-lined bins were stored for 12 mo at -3, 2, and 4° C. After storage, dates of all grades were lower in natural and waxy and higher in No. 1 dry grades of fruit in unlined than in lined bins. Soluble pigment content increased in dates in all storage treatments. Soluble pigment content was significantly higher in No. 1 dry dates of grade B in unlined than in lined bins. Some of the sucrose inverted to fructose and glucose in natural and waxy dates in grade A, but sugars did not significantly differ between dates in unlined and lined bins. Shear force measurements neither changed much during storage nor showed differences between dates in unlined and lined bins. We concluded from the tests and visual observations of the dates that storage in lined bins was beneficial to the dry grades but not to moist grades of dates.

ACKNOWLEDGEMENT

We thank John Davies, Quality Control Department of Cal-Date Company, for making storage and sampling arrangements and for helpful discussions, and Elmer Jefferies, USDA grader, for supervising all the USDA grading. The Cal-Date Company furnished the dates used in the tests. C. W. Coggins of the University of California, Riverside, kindly furnished the Allo-Kramer shear press.

LITERATURE CITED

1. Hasegawa, S., D. C. Smolensky, and V. P. Maier. 1972. Hydrolytic

enzymes in dates and their application in the softening of tough dates and sugar wall dates. Date Growers' Inst. Rep. 49:6-8.

2. Nash, P. A., and R. M. Perkins. 1975. Analysis of USDA door-grade sampling procedures for dates. Date Growers' Inst. Rep. 52:30-33.
3. Norman, S. M., L. G. Houck, D. C. Fouse, and J. W. Snider. 1975. Changes in quality of field run Deglet Noor dates stored outdoors and under refrigeration: A progress re-

port. Date Growers' Inst. Rep. 52:25-29.

4. Rygg, G. L. 1975. Date development, handling, and packing in the United States. U. S. Department of Agriculture Handbook No. 482, 56 p.
5. Smolensky, D. C., W. R. Raymond, S. Hasegawa, and V. P. Maier. 1975. Enzymatic improvement of date quality. Use of invertase to improve texture and appearance of "sugar wall" dates. J. Sci. Food Agric. 26:1523-1528.

Table 1. Grades of dates^a found by packinghouse grading of early-, mid-, and late-season Deglet Noor dates of Test 1 stored 0 - 5 mo outdoors followed by 7 - 12 mo in cold storage

Season	Grade	Months in storage outdoors					
		0	1	2	3	4	5
Early		%	%	%	%	%	%
	High No. 1 Dry	17	15	14	9	13	11
	Low No. 1 Dry	45	45	40	42	41	46
	Total marketable as whole fruit	62	60	54	51	54	57
	Products	34	37	42	45	41	40
	Culls	4	3	4	4	5	3
Mid	Waxy	0	0	0	0	1	0
	High No. 1 Dry	40	45	55	18	10	7
	Low No. 1 Dry	44	39	32	60	62	57
	Total marketable as whole fruit	84	84	87	78	73	64
	Products	13	12	11	20	26	33
	Culls	3	4	2	3	1	3
Late	Waxy	33	17	20	6	1	7
	High No. 1 Dry	47	55	31	17	4	17
	Low No. 1 Dry	9	13	2	6	0	1
	Total marketable as whole fruit	89	85	53	29	5	25
	Products	5	6	35	59	84	49
	Culls	6	7	12	12	11	26

^aValues represent the average of 3 bins of dates and are expressed in % by wt.

Table 2. Sugar content^a of natural, waxy, No. 1 dry, and No. 2 dry dates from three storage grades of dates of Test 2 before and after 12 mo storage at -3 to 4°C in unlined and polyethylene-lined bins^b

Storage grade	USDA grade	At harvest			After storage 12 mo		
		Fructose	Glucose	Sucrose	Fructose	Glucose	Sucrose
		%	%	%	%	%	%
"A"	Natural	12.7 $\pm$ 1.5	14.6 $\pm$ 0.7	55 $\pm$ 10	18.0 $\pm$ 1.1	18.3 $\pm$ 1.0	50 $\pm$ 2
	Waxy	12.0 $\pm$ 0.7	13.6 $\pm$ 1.1	53 $\pm$ 5	17.2 $\pm$ 1.2	17.5 $\pm$ 1.1	50 $\pm$ 3
"B"	No. 1 Dry	9.9 $\pm$ 0.8	10.6 $\pm$ 0.9	58 $\pm$ 2	11.5 $\pm$ 1.2	11.9 $\pm$ 1.4	60 $\pm$ 3
"C"	No. 1 Dry	10.1 $\pm$ 0.6	11.1 $\pm$ 0.6	58 $\pm$ 2	11.9 $\pm$ 2.3	12.0 $\pm$ 2.0	60 $\pm$ 4
	No. 2 Dry	8.3 $\pm$ 0.6	9.8 $\pm$ 0.8	60 $\pm$ 4	9.8 $\pm$ 1.8	10.2 $\pm$ 1.9	63 $\pm$ 2

^aValues represent the average $\pm$ the standard deviation of 6 bins and are expressed as % dry wt. of flesh.

^bValues for dates in unlined and lined bins did not differ and values were combined.

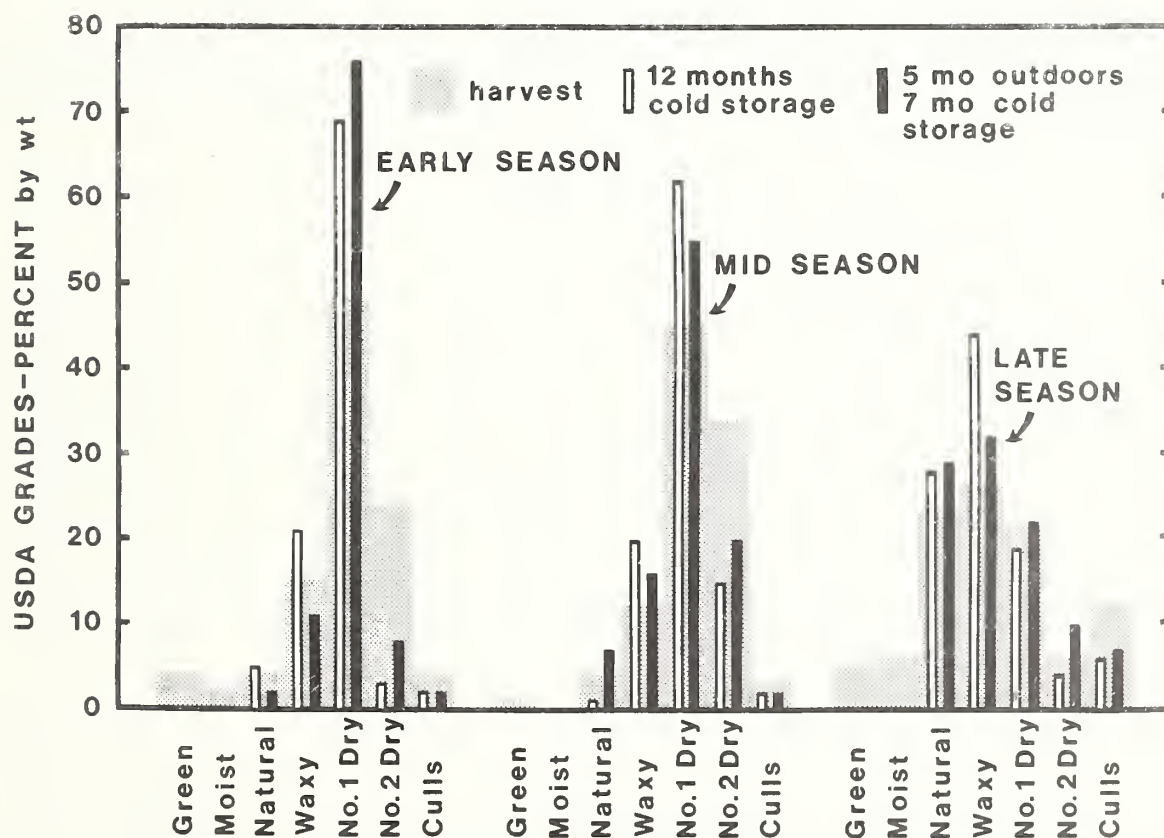


Figure 1. Grades of dates determined by USDA graders at harvest, after outdoor storage 5 mo followed by cold storage 7 mo, and after cold storage 12 mo.

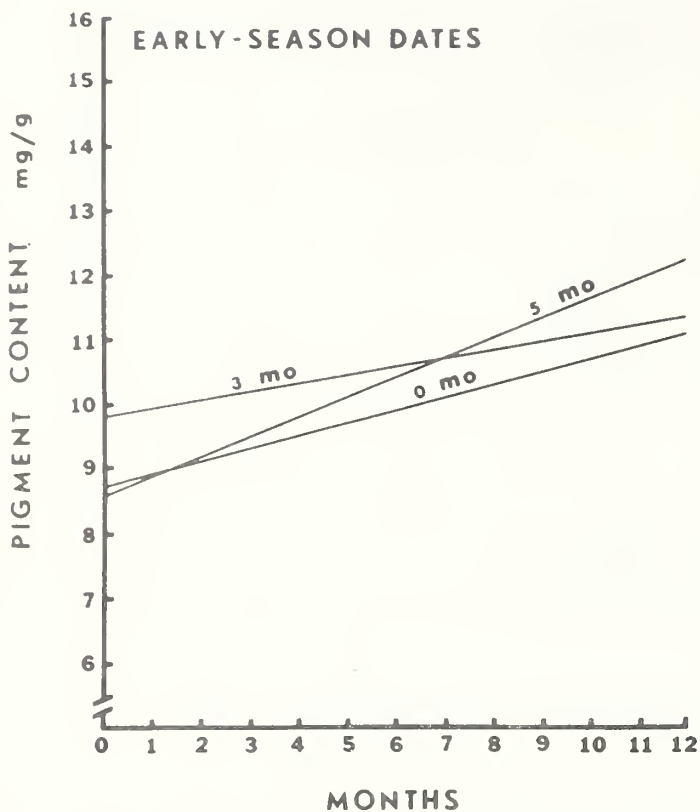


Figure 2. Soluble pigment content in mg/g dry wt of flesh of early season dates held outdoors 0, 3, and 5 mo followed by cold storage 12, 9, and 7 mo, respectively.

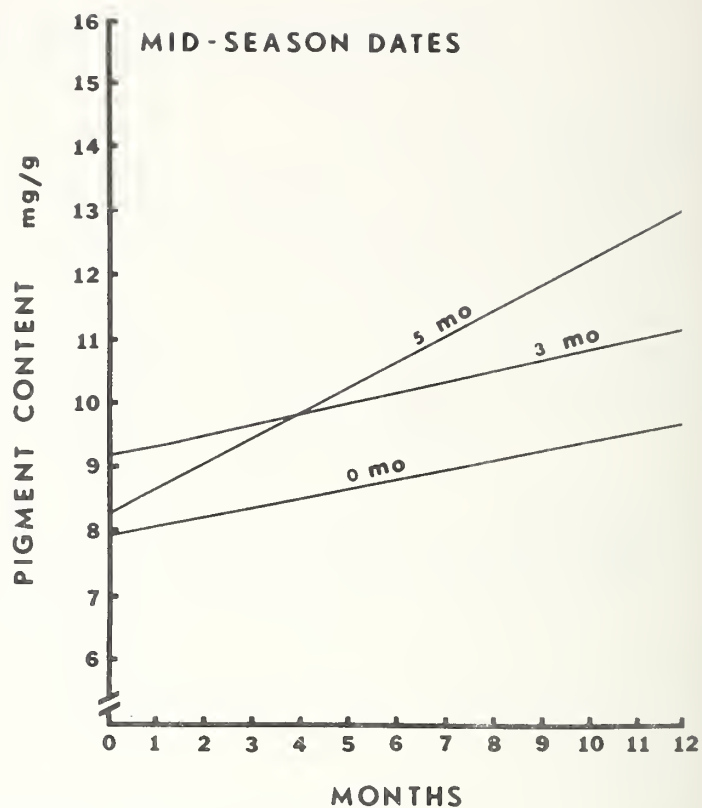


Figure 3. Soluble pigment content in mg/g dry wt of flesh of mid-season dates held outdoors 0, 3, and 5 mo followed by cold storage 12, 9, and 7 mo, respectively.

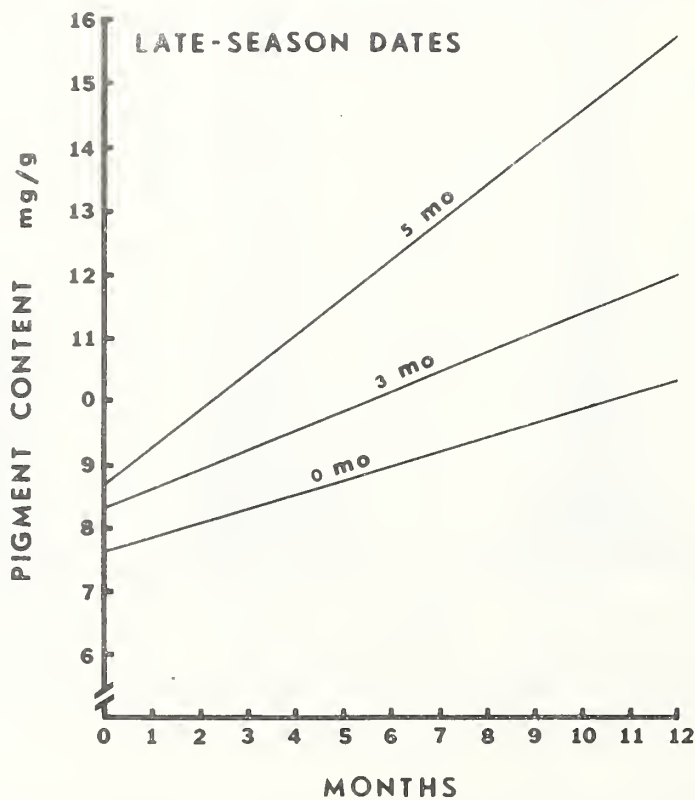


Figure 4. Soluble pigment content in mg/g dry wt of flesh of late-season dates held outdoors 0, 3, and 5 mo followed by cold storage 12, 9, and 7 mo, respectively.

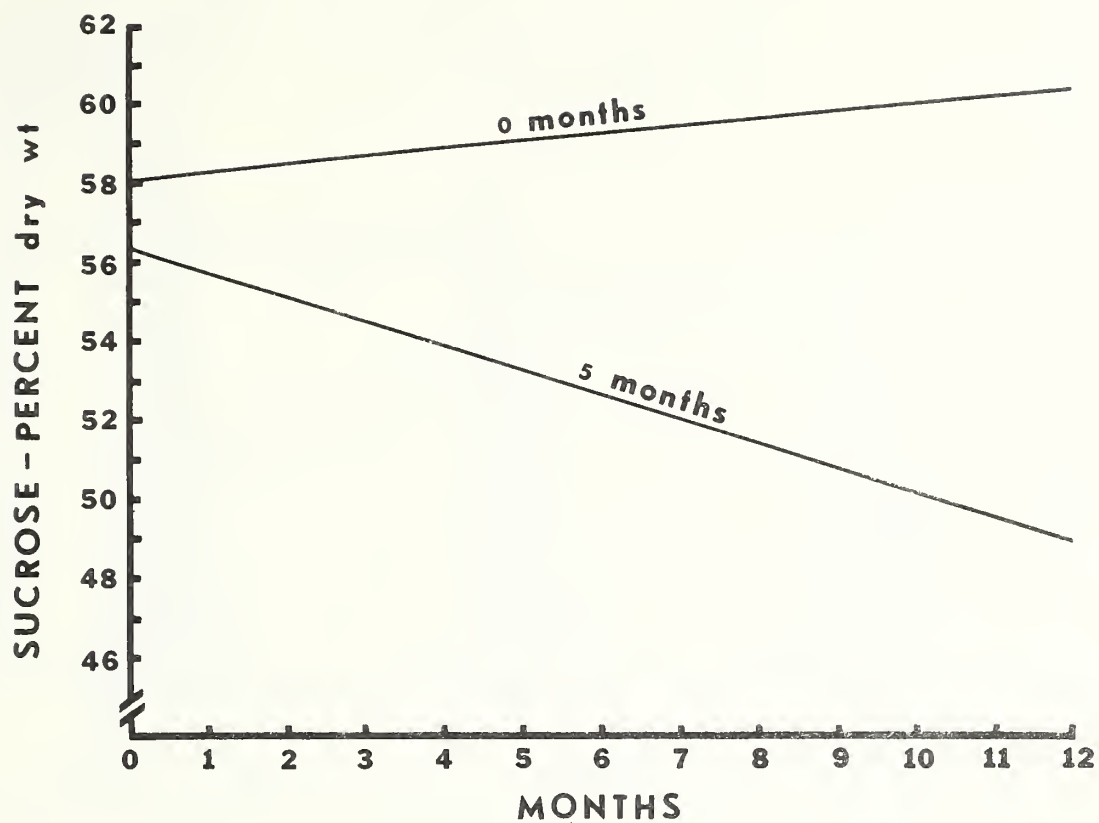


Figure 5. Sucrose content of dates held outdoors 0 and 5 mo followed by cold storage 12 and 7 mo, respectively.

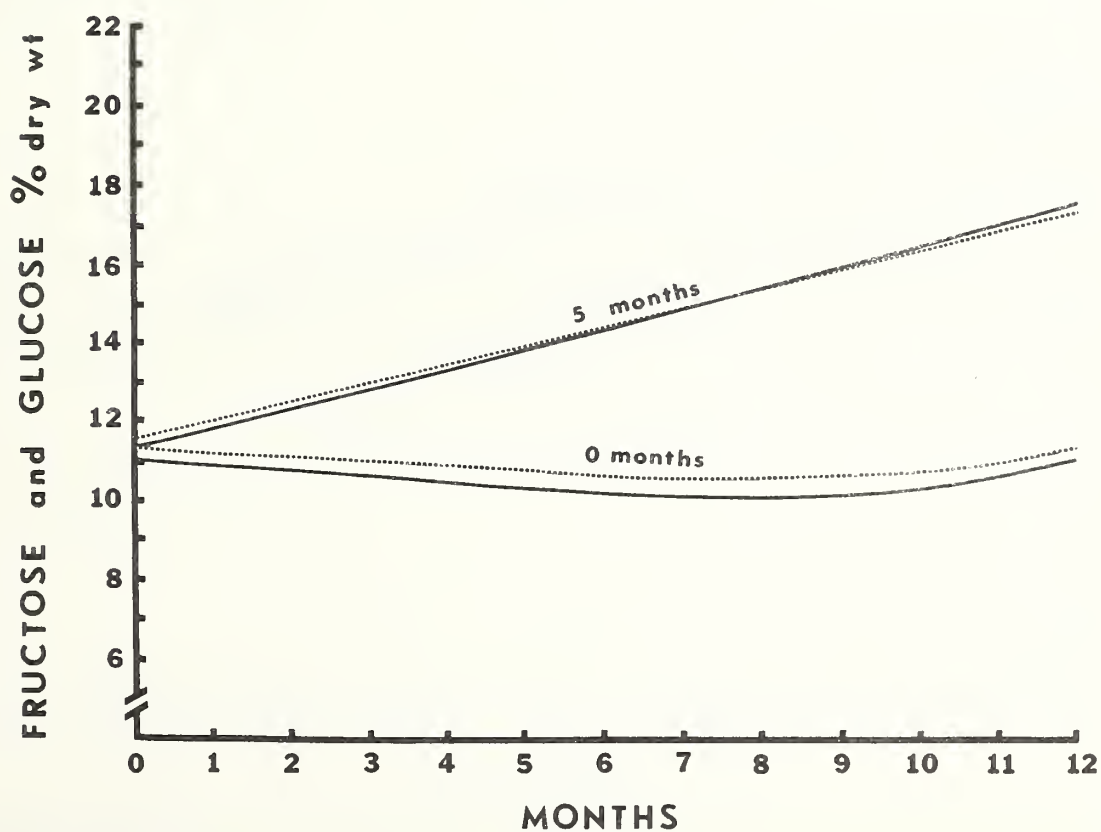


Figure 6. Fructose (solid line) and glucose (broken line) content of dates held outdoors 0 and 5 mo followed by cold storage 12 and 7 mo, respectively.

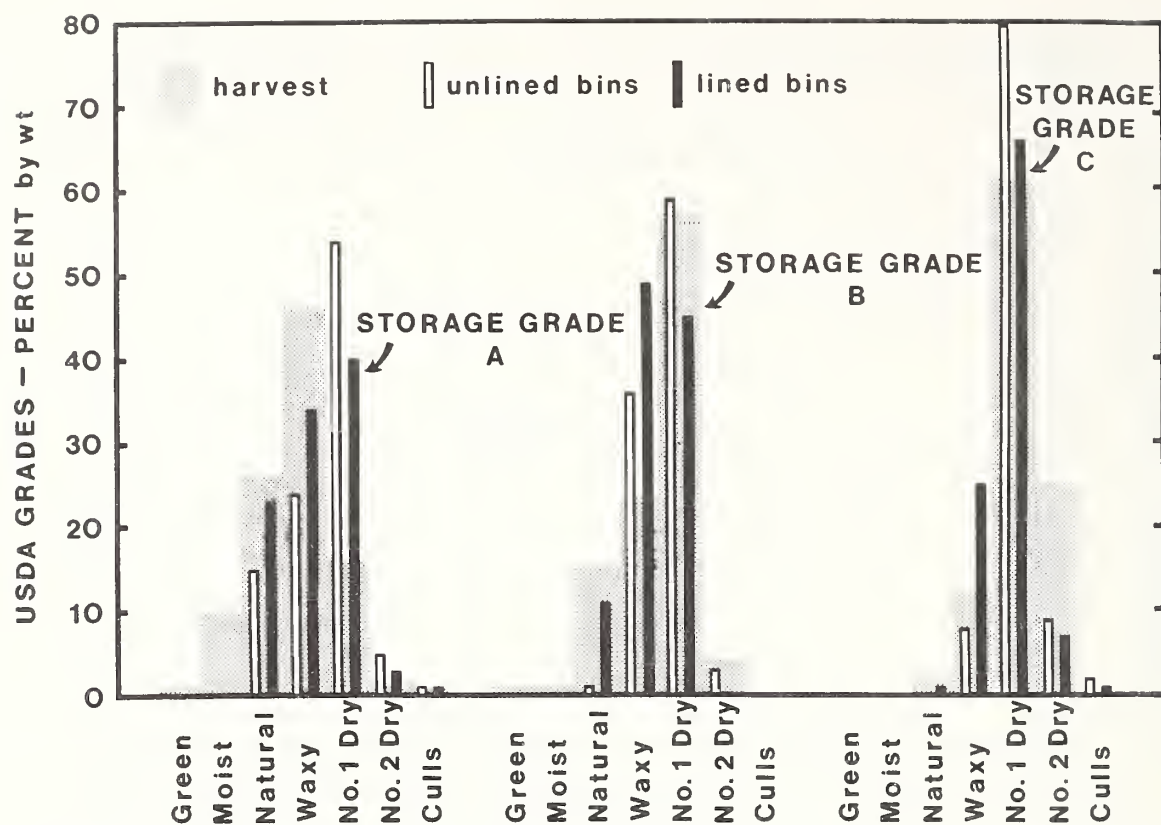


Figure 7. Grades of dates determined by USDA graders for 3 storage grades of mid-season dates at harvest and after 12 mo storage at -3 and 4°C in unlined and polyethylene-lined bins.

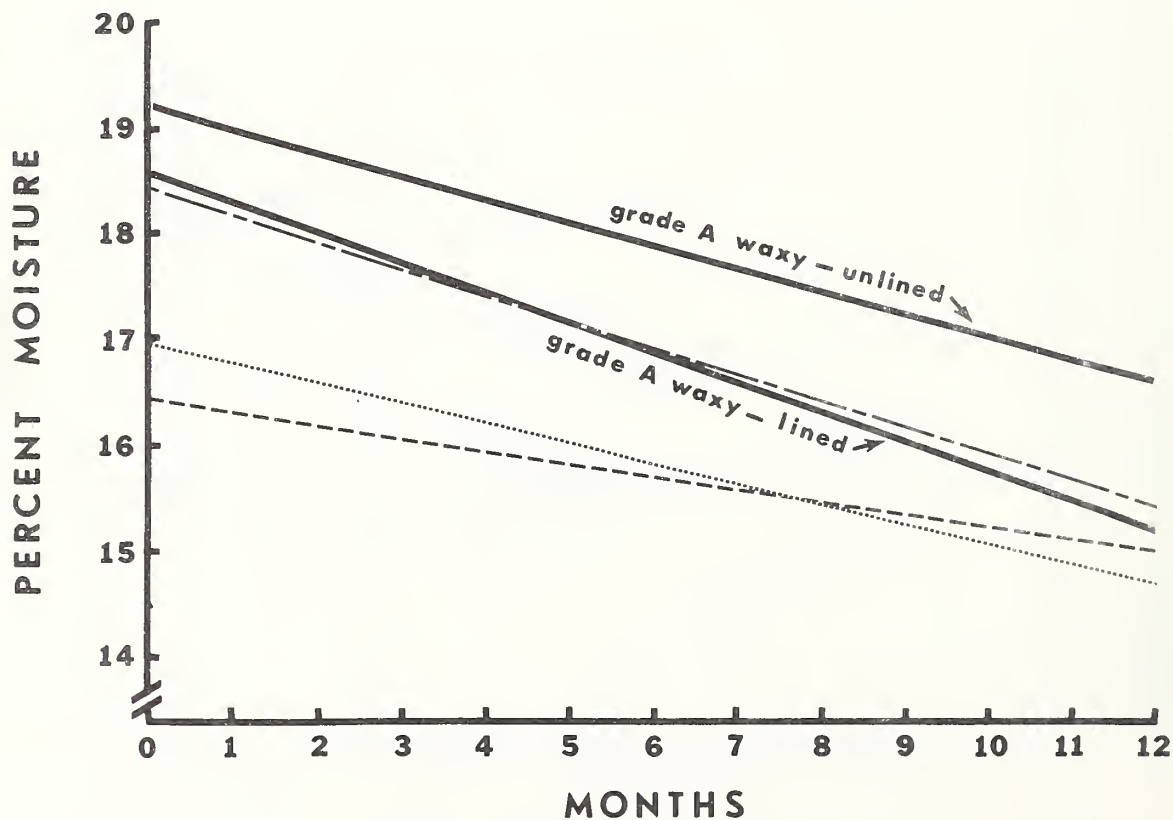


Figure 8. Moisture content of waxy fruit of storage grade A in unlined and lined bins during 12 mo storage (heavy black lines), No. 1 dry dates from grade B (---), and No. 1 dry (.....) and No. 2 dry (-----) dates of grade C.

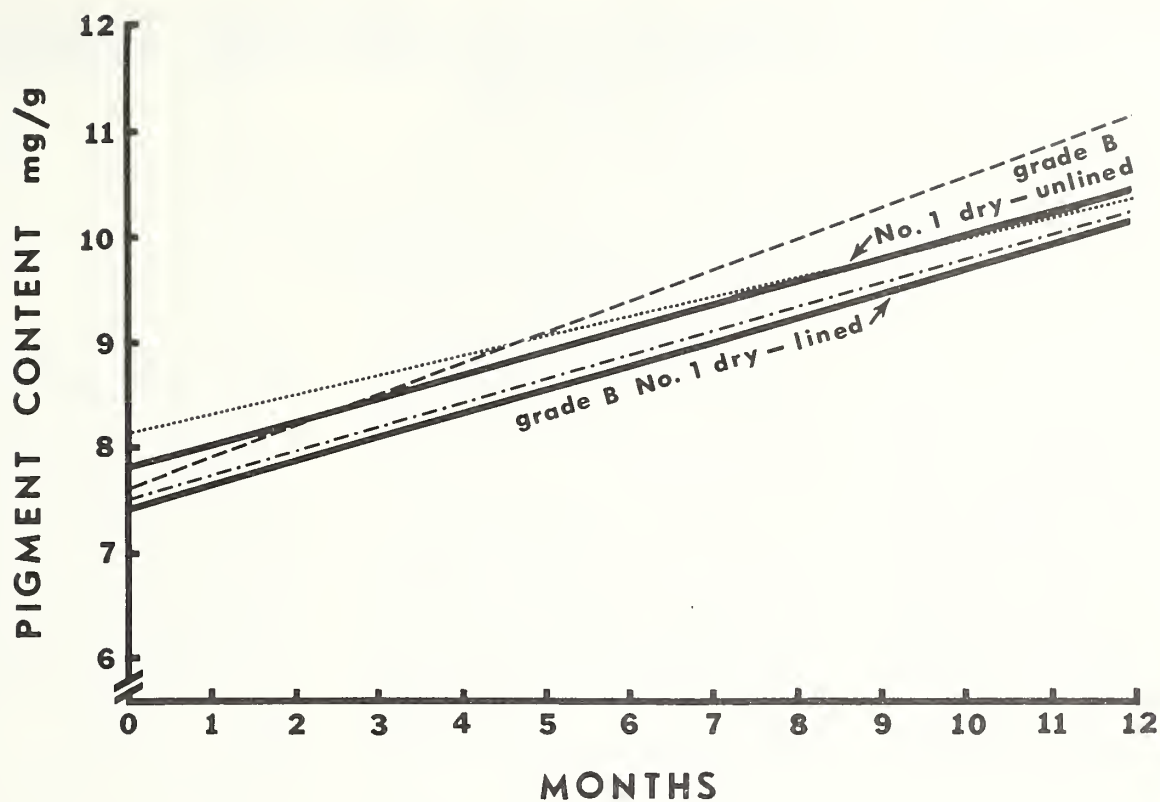


Figure 9. Pigment content in mg/g dry wt of flesh of No. 1 dry dates of storage grade B in unlined and lined bins (heavy black lines), waxy dates of grade A (- - - - -), and No. 1 dry (.) and No. 2 dry (- - - - -) dates of grade C during 12 mo storage.

APPLICATION OF NEAR-INFRARED MOISTURE ANALYSIS TO DATES¹

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ABSTRACT

A near-infrared method for determining moisture content of dates compared favorably with a vacuum-oven method, except for No. 2 dry dates. The differences between the two methods were not significant for natural, waxy, and No. 1 dry dates. Moisture values by the vacuum-oven method were 0.37 percentage points higher than the near-infrared values for No. 2 dry dates. The NIR method is specific for water, more rapid than vacuum-oven drying, and suitable for small samples. The homogenate may be used for other determinations such as sugar and pigment analyses.

Date Growers' Inst. Rep. 53:18

During investigations of quality changes in dates during storage, it became necessary to determine moisture contents of small samples used for sugar and pigment measurements. Methods commonly used to measure the moisture content of dates are vacuum-oven drying at 70° C or lower, measurement of the electrical conductance of ground samples with a dried-fruit moisture tester (1), or partial freeze drying followed by vacuum-oven drying (2).

Hart, Norris and Golumbic (5) used the near-infrared (NIR) absorption bank of water at 1930 nm to measure moisture content that varied from 3-19% in cereals. Gold (4) extended this method to measure moisture contents that varied from 2-99% in fruit and vegetable materials.

¹ Mention of a proprietary product in this paper does not constitute a recommendation or an endorsement of the product by the U.S. Department of Agriculture.

He measured the absorption at 1940 nm. Our paper describes the application of these NIR methods to dates and compares the NIR method with the vacuum-oven drying method.

MATERIALS AND METHODS

Deglet Noor dates were cut lengthwise and pitted. Two samples were made from the halves of each of 25 dates. One sample was dried under the vacuum (100 mm Hg) at 65° C for 72 hours and its moisture content determined gravimetrically.

The other sample was cut into about 10 mm pieces with poultry shears and weighed in a tared, 1 liter graduated cylinder (cut off and fire polished at the 700-ml mark to fit the shaft of the Polytron). An equal weight of anhydrous methanol was added, and the dates were disintegrated in 1 min with a Brinkmann Model PT-45/2 Polytron. A 10-g sub-sample (5 g dates) of the homogenate was weighed into a tared 125-ml Erlenmeyer flask equipped with a glass stopper, and anhydrous methanol (100 ml) was added. The flask was stoppered and put in an ultrasonic bath for 2-3 min, then left overnight at room temperature.

Some of the methanol extract was transferred with a dropping pipet, without disturbing the residue, to a 1-cm Infrasil cell which was then stoppered. The sample and reference cells were placed in a Beckman Acta M IV spectrophotometer, and absorbance was set at 0 at 1830 nm, where water has no absorption. The absorbance of the water in the sample was measured at 1940 nm and the reference cell was removed from the instrument between readings so that heating was minimized. Moisture content was found by reference to the absorbance of a standard, freshly prepared by the addition of 1.0 g water and 5.0 g methanol to 100 ml methanol. The same lot of me-

thanol was used for sample preparation, the standard, and the reference.

RESULTS AND DISCUSSION

For the preparation of samples, pitted dates are usually ground with a food chopper, then mixed thoroughly. Problems result from this procedure: (a) dates are difficult to mix after grinding and must be kneaded like bread dough, (b) heat is produced during the grinding process and constituents, particularly the sugars, may undergo heat-induced decomposition, (c) small samples are lost in the food chopper, and (d) cleaning and drying the food chopper between samples is time consuming. Thus, alternative methods for sample preparation were investigated. A blender will not completely disintegrate dates and it generates excessive heat during blending. A Polytron was found to be effective, it disintegrates dates by the combined actions of high-pressure recycling and mechanical shearing. Both large and small samples were homogenized in 1 min or less with little generation of heat.

Moisture of 90 different samples of dates was determined by the NIR and vacuum-oven methods (Table 1). Four grades of dates from experimental storage tests were used. Of these grades, natural dates are generally the most moist and No. 2 dry dates the least. According to "t" tests for paired observations, the differences between the two methods are not significant for natural, waxy, and No. 1 dry dates. The vacuum-oven values average 0.37 percentage points higher than the NIR values for No. 2 dry dates; this is significant at the 0.01 level. However, this is within the 0.5% accuracy of the vacuum-oven method (6). Standards for the NIR method gave an absorbance reading of 0.610 ± 0.010 ($n = 29$).

The accuracy of a particular method of analysis cannot be tested absolutely

because the true moisture content is not known. The tendency of some constituents, particularly sugars, to decompose with the evolution of water and other volatile constituents, and the formation of browning reaction products in dates when heated have been reported (7,8). Deglet Noor dates contain 80-85% sugar (3). The contribution of such decomposition in dates to moisture values obtained from vacuum-oven drying is not known. The NIR method is specific for water, more rapid than vacuum-oven drying, and suitable for small samples. The homogenate may be used for other determinations such as sugar and pigment analyses.

LITERATURE CITED

1. AOAC. 1975. Official Methods of Analysis, Sec 22.013 and 22.014, *In* Assoc. Official Anal. Chem., Washington, D.C.
2. Coggins, C. W., Jr., and J. C. F. Knapp. 1969. Growth, development, and softening of the Deglet Noor date fruit. *Date Growers' Inst. Rep.* 46:11-14.
3. Cook, J. A., and J. R. Furr. 1953. Kinds and relative amounts of sugar and their relation to texture in some American-grown date varieties. *Proc. Am. Soc. Hort. Sci.* 61:286-292.
4. Gold, H. J. 1964. General application of near-infrared moisture analysis to fruit and vegetable materials. *Food Tech.* 18:586-587.
5. Hart, J. R., K. H. Norris, and C. Golumbic. 1962. Determination of the moisture content of seeds by near-infrared spectrophotometry of their methanol extracts. *Cereal Chem.* 39:94-99.
6. Joslyn, M. A. 1970. *Methods in food analysis*. 2nd ed. Academic Press, N. Y.
7. Maier, V. P., and F. H. Schiller. 1961. Studies on domestic dates. II. Some chemical changes associated with deterioration. *J. Food Sci.* 26:322-328.
8. Maier, V. P., and D. M. Metzler. 1965. Changes in individual date polyphenols and their relation to browning. *J. Food Sci.* 30:747-752.

Table 1. Comparison of moisture values for four grades of Deglet Noor dates by the near-infrared (NIR) and vacuum-oven methods

% Moisture								
Grades	Natural		Waxy		No. 1 dry		No. 2 dry	
Methods	NIR	Vacuum	NIR	Vacuum	NIR	Vacuum	NIR	Vacuum
	20.90	20.98	15.60	16.19	15.42	16.06	14.68	15.28
	19.35	19.88	15.84	16.23	14.81	14.83	12.70	13.29
	17.97	17.72	16.26	16.41	15.33	15.40	15.38	15.63
	17.21	17.21	15.48	15.81	15.92	15.86	14.53	14.61
	18.06	17.92	16.13	16.12	16.96	17.38	14.59	14.54
	17.20	17.22	16.41	16.49	16.02	16.47	11.05	12.18
	24.12	24.29	16.52	16.37	16.05	16.10	14.39	13.92
	23.55	24.28	17.11	17.27	17.70	17.53	15.66	15.96
	22.09	22.19	18.68	18.88	18.21	18.25	15.12	15.40
	21.01	21.32	17.67	17.32	17.69	18.24	15.95	16.85
	22.79	21.28	17.10	16.88	17.34	17.68	16.02	16.12
	18.98	19.04	19.78	19.48	16.95	17.52	14.83	15.03
	22.31	21.68	18.66	18.64	17.93	17.23	14.46	15.28
	22.75	21.55	17.12	17.13	16.35	16.94	14.97	15.50
	22.07	22.16	17.63	17.66	16.72	17.25	15.62	16.31
	20.87	21.29	16.52	16.48	16.04	16.62	13.77	13.94
	20.34	19.80	18.34	18.27	15.42	15.98	16.93	16.93
	20.53	20.62	16.36	16.51	15.88	16.26	13.04	13.41
	20.26	20.50	15.31	15.73	15.88	15.94	13.99	14.16
	20.00	20.28	15.90	16.27	19.27	18.25	13.81	14.37
			15.16	15.73	17.84	18.05		
			15.72	17.09	19.26	18.90		
			17.32	18.19	19.47	19.54		
			19.11	19.58	19.17	18.72		
			18.65	18.87	18.15	18.47		
Mean	20.62	20.56	16.98	17.18	17.03	17.18	14.57	14.94
Std Dev	±2.04	±2.02	±1.30	±1.19	±1.38	±1.20	±1.32	±1.24
t ^a	0.489		2.761		1.710		3.209*	

^aAsterisk denotes statistical significance at 0.01 for a two-tailed "t" test.

METAXENIA EFFECT OF POLLEN FROM INBRED MALE PALMS ON RIPENING PERIOD AND SIZE OF DATE FRUIT

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ABSTRACT

In metaxenia studies, pollen from six inbred male palms were compared with Fard 4 pollen, which induces early ripening, in pollination of Deglet Noor palm flowers. None of the six induced earlier ripening than Fard 4. Variation in the effect of pollen on the time of ripening was as great within the inbred lines as between different inbred lines.

Date Growers' Inst. Rep. 53:21

The metaxenia effect of pollen on the fruit of the date palm, *Phoenix dactylifera* L., has been of interest to date growers for many years. Swingle (9) proposed the term "metaxenia" to describe the direct effect of pollen upon seed and fruit tissues lying outside the embryo and endosperm. Studies by Nixon (1, 6) demonstrated the influence of pollen from different sources upon time of ripening, fruit size, seed size and shape of 'Deglet Noor' fruit and the fruit of several other date cultivars. Nixon (5) also demonstrated that the use of a pollen which causes early ripening can be valuable to growers in areas where late-ripening dates may be damaged by rain. Osman, et al., (7) found that pollen from different male palms significantly influenced the frequency distribution curves of such characters as weight of seed and pericarp; pollen of an inbred Deglet Noor clone produced the least dispersion about the means for these characters. They suggested that a part of the spread in time of ripening of the fruit on a given bunch of dates was related to the heterozygosity of pollen used and that, by inbreeding to reduce the variability of the pollen, the ripening period of the fruit on bunches pollinated with such pollen might be shortened, but only slightly because half of the variability is due to the egg.

This paper reports on the results of two experiments conducted to study possible

metaxenia effects of pollens from several inbred males, to determine whether differences existed and whether any pollens induced large size of fruit and reduced the spread of ripening time.

MATERIALS AND METHODS

The procedures followed in these experiments were similar to those described by Nixon (3). Male and female spathes were covered with brown paper bags as soon as they emerged. Male inflorescences were cut as soon as the spathes cracked and, after removal of the spathes, were placed on trays in separate rooms to dry. Female inflorescences were opened after the spathes cracked and were thinned by cutting back the tips, removing some of the center strands, and leaving 40 strands on each bunch. The strands were separated into groups of 10 strands and each group was covered with a paper bag.

Seedling male clones used in the two experiments were selected from backcrossed lines as follows: 63-394-21 'Khadrawy' BC₃, 63-394-25 Khadrawy BC₃, 63-396-7 'Medjool' BC₃, 63-396-9 Medjool BC₃, 64-354-15 Deglet Noor BC₄, 64-354-22 Deglet Noor BC₄. A 'Fard 4' male was used as a standard because this clone induces early ripening. Two 17-year-old Deglet Noor female palms were used in each experiment and each pollen treatment was applied to five bunches. All the experimental palms were located in the same row on the U.S. Date and Citrus Station, Indio, California, and received uniform care.

Pollination was accomplished by punching a small hole in the paper bag covering the female inflorescence and blowing the pollen into the bag with a plastic wash bottle. The hole was then sealed with tape. All treatments were applied on the same day.

Harvest dates were September 23, September 30, October 7 and October 21. The ripe dates were picked from

each group of strands and weighed. From these lots, 10 dates were randomly selected. If there were less than 10 dates in the lot, all of the dates were used. These samples were deseeded and the flesh was dried in a forced-draft oven at 70° C for 48 hr. The weight of the dried pericarp was recorded immediately after removal from the oven. Seeds were placed on wire trays, air-dried for 6 days and weighed.

RESULTS AND DISCUSSION

As reported in previous studies (1, 2, 3, 4, 5, 6, 7, 9) Fard 4 pollen caused earlier ripening of Deglet Noor fruit than did any of the other pollens tested in the two experiments (Fig. 1). Pollen of Khadrawy seedling 63-394-25 also caused early ripening, but not as early as that induced by Fard 4 pollen. The latest ripening fruit resulted from the use of pollen of Deglet Noor seedling 64-354-22. On October 7, 96% of the Fard 4 pollinated fruit and 63% of the Deglet Noor seedling 64-354-22 pollinated fruit had ripened.

Fard 4 pollen also produced fruit with smaller seed than did the other pollens (Table 1). Differences in pericarp weight between fruit derived from Fard 4 pollen and Khadrawy 63-394-25 pollen in experiment I and Fard 4 pollen and Khadrawy 63-394-21 pollen in experiment II were not significant. The small differences in pericarp weight found in experiment II may have been due to the prevalence of blacknose in fruit of these bunches.

The variation in the effect of pollen on the time of ripening appears to be as great within the backcrossed lines as between these lines (Fig. 1). For example, the curves representing the two siblings in the same Deglet Noor line are no more similar to each other than they are to the curves representing the Medjool or Khadrawy lines.

Although the different pollens influenced the initiation of ripening in fruit,

it does not appear that any pollen tested appreciably influenced the duration of the ripening period as compared to Fard 4 as a standard. The time of receptivity of different flowers on the same inflorescence may vary by 2 wk or more (8). This variation in the time of receptivity and, consequently, of fertilization of the egg may play an important part in determining the duration of the ripening period, and the degree of homozygosity of pollen may have little influence on duration of the ripening period. Additional male palms should be tested to determine those most useful in developing pollen sources that can produce an early onset of the ripening period or that induce large size of fruit.

SUMMARY

The metaxenia effect of pollen from several inbred male palms was studied. None induced earlier ripening in Deglet Noor fruit than did pollen from the Fard 4 male. The variation in the effect of pollen on the time of ripening appeared to be as great within the inbred lines as between the different inbred lines and none appeared to shorten the duration of the ripening period of the fruit on the same bunch when compared to Fard 4 as a standard.

LITERATURE CITED

1. Nixon, R. W. 1926. Experiments with selected pollens. Date Growers' Inst. Rep. 3:11-14.
2. Nixon, R. W. 1927. Further evidence of the direct effect of pollen on the fruit of the date palm. Date Growers' Inst. Rep. 4:7-9.
3. Nixon, R. W. 1928. The direct effect of pollen on the fruit of the date palm. J. Agric. Res. 36:97-128.
4. Nixon, R. W. 1928a. Immediate influence of pollen in determining the size and time of ripening of the fruit of the date palm. J. Hered. 19:241-255.
5. Nixon, R. W. 1931. The commercial utilization of differences in time of ripening of dates due to pollen. Date Growers' Inst. Rep. 8:5-6.
6. Nixon, R. W. 1934. Recent pollination experiments. Date Growers' Inst. Rep. 11:9-11.
7. Osman, A. M. A., W. Reuther, and L. C. Erickson. 1974. Xenia and metaxenia studies in the date palm *Phoenix dactylifera* L. Date Growers' Inst. Rep. 51:6-16.
8. Ream, C. L., and J. R. Furr. 1969. The period of receptivity of pistillate flowers and other factors affecting set of date fruit. Date Growers' Inst. Rep. 46:28-29.
9. Swingle, W. T. 1928. Metaxenia in the date palm, possibly a hormone action by the embryo or endosperm. J. Hered. 19:257-268.

Table 1. Effect of different pollens on weight of seed and pericarp of Deglet Noor fruit

	Seed weight (g)	Pericarp weight (g)
Experiment I		
64-354-15 ^x Deglet Noor BC ₄	.807 a	8.40 a ^y
63-396-7 Medjool BC ₃	.790 a	8.15 a b
63-394-25 Khadrawy BC ₃	.759 a	7.85 b c
Fard 4	.650 b	7.62 c
Experiment II		
64-354-22 Deglet Noor BC ₄	.836 a	8.51 a
63-396-9 Medjool BC ₃	.812 a	8.50 a
63-394-21 Khadrawy BC ₃	.752 b	8.29 a b
Fard 4	.680 c	8.01 b

^x U.S. Date and Citrus Station accession number.

^y Comparable mean separation by Duncan's multiple range test at the 5% level.

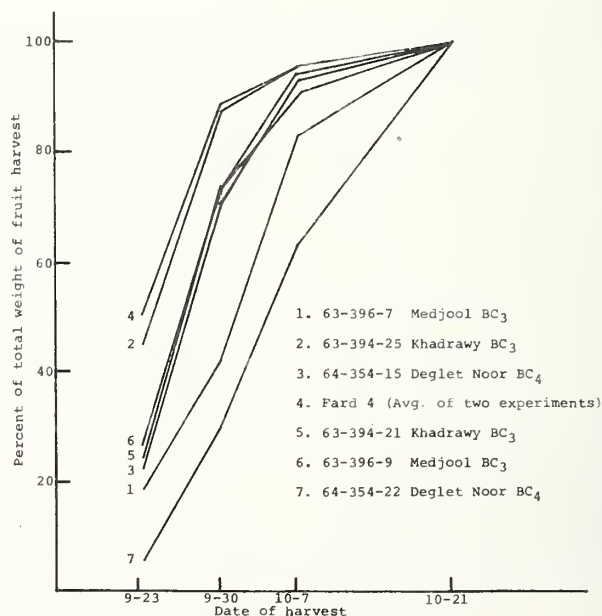


Figure 1. Influence of pollen on percent of fruit harvested by 9/23, 9/30, 10/7, and 10/31 — 1975.

THE POLLEN HUSTLERS: COOPERATIVE OWNERSHIP AND EXTRACTION OF DATE POLLEN

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ABSTRACT

A date growers' cooperative was organized in 1976 for the mechanical extraction of pollen. Recommendations are made for developing a growers' cooperative that would collect, extract, store and distribute pollen. Eventually, orchards of male palms might be established for production of pollen.

Date Growers' Inst. Rep. 53:23

In 1974, Agricultural Engineers Paul Burkner of the Agricultural Research Service, U. S. Department of Agriculture, and Roger Perkins, of the University of California, Riverside, developed a machine for extracting pollen from male blooms.

The advantages of the mechanical extractor over past methods of pollen extraction include increased yield of pollen, savings in labor costs and reduction of the health hazard arising from allergy to date pollen.

It was the opinion of the engineers that, due to the cost and capacity of the extractor, a program of cooperative ownership and use would be more feasible than individual ownership. With their assistance and the use of their extractor, a pilot program was conducted in 1975 by growers Lee Anderson, Jr., Sunar Chuchian, Peter Dondero, Harold Ensley, David Mitchell and me, that involved extracting pollen for use on a total of 530 acres. The extractor was used for 46 operating hr over a period of 41 days.

With data gathered during the 1975 program, the engineers compiled a projection on the cost of operating the pollen extractor based on: 10 growers, 800 acres of palms, a machine cost of \$5,000, and a yearly operation cost of \$450. On the basis of their calculations, the extraction cost per quart of pollen was \$0.95.

The findings of the 1975 pilot program have borne out the engineers' belief that the amount of time one grower would use the extractor in a given season would not warrant the cost of individual purchase. The capacity of the machine exceeded the needs of the individual grower in Coachella Valley. Therefore, the conclusion was reached that cooperative use and ownership of the extractor was the most practical and desirable arrangement.

At the end of the 1975 pollinating season, the above listed growers, plus Hadley Date Gardens, met and formed a cooperative, calling it "The Pollen Hustlers" and contracted locally to have a machine built at a cost of \$4,500. Two of seven growers involved had such small acreages that the initial cost of the extractor was split into six equal shares:

During the 1976 pollinating season, the extractor was used for 134 hr to provide pollen for pollinating a total of 740 acres of female palms. Operating costs were divided equally in this first year of operation as a cooperative. The biggest problem encountered was the frequent mechanical breakdown of the extractor; however, the contractor who built the machine was cooperative in making repairs.

It is the unanimous opinion of "The Pollen Hustlers" that the cooperative pollen extraction program has been beneficial to everyone.

I feel that the success of the 1976 cooperative effort opens up other possibilities for cooperative pollen collection and, eventually, for the growing of male pollen gardens for pollen production. For example, the present method is for each grower to use his own labor and trucks to collect pollen and to maintain his own pollen room. The area bounded by Avenue 56 and 58, Van Buren and Monroe Streets has twelve date growers, each collecting pollen. During the bloom season, with two or more employees

collecting pollen for each grower in gardens located in very close proximity to each other, the traffic at Avenue 56 and Jackson gets very heavy.

Consideration should be given this coming year to implementation of a cooperative route collection system, using past experience to establish the number of palms two men and a truck could handle daily. The use of marked containers for collecting blooms would properly identify each grower's pollen.

A centrally located pollen room and an extractor could be set up for use by participating growers. Each grower could be assigned a specific area for pollen storage. One man in the pollen room could hang blooms to dry, use the extractor and dry the extracted pollen. Each participating grower would have access to the pollen storage room in order to take pollen as needed.

The economic advantages of this pollen handling system should be reflected in reduced labor, equipment and time required to do the job. A man trained and employed for the duration of the season would become familiar with the equipment and its operation, and the number of breakdowns would probably decrease.

In my opinion, a fully developed cooperative program would be based on a male palm garden. The palms might be planted on 25-ft centers, rather than the normal 30-ft centers for female palms; this spacing would give 70 male palms per acre. The extractor and a pollen room could be set up at the same location.

This plan, which would entail the transplanting of bearing male palms, and offshoots, could become operational within 5 years. The advantages of this integrated plan over the present method of pollen collection would include:

1. A compact area in which to gather pollen.
2. Minimal labor requirements, com-

pared to present diffuse pattern of collection.

3. Improved pollen recovery, because handling and transportation of inflorescences would be reduced.
4. Minimal transportation, hours of vehicle operation, vehicle accidents, and energy consumption.
5. Sufficient numbers of palms to justify use of a man-positioner in harvesting blooms.
6. A pollen bank from which pollen could be sold to non-member date growers.
7. Elimination of male palms from regular orchards, thus increasing the space available for female palms.

DATE PALM BREEDING, A REVIEW¹

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ABSTRACT

Literature pertinent to the breeding of the date palm, *Phoenix dactylifera*, is reviewed and includes references to taxonomy, cytology, metaxenia, and utilization of species within the genus *Phoenix*. Date palm breeding is discussed in relation to improved quality, yield, and handling properties in commercial date varieties; improved resistance and fruit quality in selections resistant to the fusariosis or bayoud disease, incited by *Fusarium oxysporum* var. *albedinis*; development of varieties for use in marginal date growing areas; and a consideration of other valuable characters, especially sugar production, of date palms and related species that might be worthy of genetic improvement.

Date Growers' Inst. Rep. 53:25

World date production was reviewed by Dowson (18), who estimated total production for 1966 at 1,826,000 metric tons from 96,000,000 trees. Yields remained fairly constant from 1961 to 1972 (21). Munier (36) detailed the geographic distribution of the date palm (*Phoenix dactylifera* L.) and other species of *Phoenix*.

Renewed interest in date culture is apparent in recent publications relating to the crop and in public and private assistance programs in developing countries. Numerous inquiries into date culture and utilization have been directed to the Agricultural Research Service from date growing countries. Interest in dates as a staple food crop is especially keen in countries bordering the western and southern Sahara, where date varieties

tolerant to sub-optimal or marginal conditions, though not of the highest quality, might provide valuable food and other products on land unsuited to other crops.

The adaption and selection of varieties for a wide range of adverse conditions was noted by Nixon (42). An excellent series of country reports on date culture in marginal areas has been published by P. Munier through the Institut Francais de Recherches Fruitieres d'Outre-Mer, Paris.

In Morocco and the western half of Algeria, fusariosis (bayoud disease), incited by *Fusarium oxysporum* Schlecht. var. *albedinis* (Killian & Maire), Malencon, has devastated most of the commercial and subsistence plantings of date palms in an area south and east of Marrakech and the Atlas Mountains (21). Pereau-Leroy (48) estimated that from the appearance of the disease in the late 1800's until 1950, more than 10,000,000 of the 15,000,000 date palms in Southern Morocco succumbed to fusariosis. Breeding and selection of good to high quality date varieties tolerant or resistant to fusariosis are required to rehabilitate oases and to restore a valuable segment of the export trade. In Algeria, disease-resistant date varieties could supplement control of fusariosis by quarantine and eradication measures (9). Spread of fusariosis into the great eastern oases that extend from Ourgala northward to Touggourt, Oued Souf, and the Biskra area would menace Algeria's valuable and indispensable date industry.

Breeding of date palms is a recent development in the culture of this ancient crop (8, 13, 22, 49, 50). Old World varieties have arisen by selection of chance seedlings adapted to local needs; some varieties have been especially suitable for domestic and foreign commerce. Prior to 1000 A.D., 120 varieties were recorded and more than 1,200 varieties have been listed within the last century (50). In California, Old World

varieties are the basis of the industry. A few local seedling selections have been named and are planted on a limited acreage.

This workshop provides an opportunity to examine date palm breeding in relation to (a) improved quality, yield and handling properties in commercial fruit varieties, (b) improved disease resistance to fusariosis, (c) development of varieties for use in marginal date growing areas, and (d) a consideration of other valuable characters of date palms and related species that might be worthy of genetic improvement.

Objectives, problems, and progress involved in breeding date palms have been discussed by Barrett (3), Nixon (42), Nixon and Furr (45), Oudejans (47), Laville (26), and Ream (51). Information on other aspects of date culture may be found in Elmer, et al., (20), Hussain (23), Munier (36), Nixon (44), Reuveni (52), and Toutain (53).

THE GENUS *Phoenix*

The diverse uses of *Phoenix* species include food in several forms for man and animals, fiber, wood, fuel, shelter, and handsome ornamental plants (1, 4, 7, 19, 32, 36, 41, 60).

The brief reference to the taxa in *Phoenix* provides a current evaluation of the species. Moore (33) listed 29 taxa of which 12 were considered valid species; he later (34) reported 17 species in *Phoenix*, but did not list them. Nineteen species recognized by one or more investigators are shown in Table 1. De Martius' (30) list of species is included for historical interest. Becarri (6) and other authors cited agree on seven species. Natural interspecific hybridization may occur wherever two or more species of *Phoenix* grow and flower close together. Under such circumstances the breeder must select his plant material with unusual care.

At the Huntington Library and Botanic Garden, San Marino, California, Myron

¹ Presented at the Palm Breeding Workshop, 29 September to 2 October 1975, Food and Agriculture Organization of the United Nations, Rome.

Kimnack is currently reviewing the species problem in *Phoenix*; F. C. Boutin and C. O. Hallberg are breeding interspecific hybrids of *Phoenix* to produce new horticultural materials for landscape use, and the excellent collection of species and hybrids of *Phoenix* is being expanded and improved.

CHROMOSOMES

Data on chromosomes in several *Phoenix* species are summarized in Darlington and Wylie (14). All investigators except Doulat (17) report 36 chromosomes in the diploid condition of seven species. Nemec (39) is cited by Doulat (17) and Beal (5) as reporting 28 chromosomes in *P. dactylifera*, whereas Nemec (39) stated that he counted 28, but believed that some long chromosomes might have been multivalent or that some chromosomes were hidden by other material in the preparations. These papers and that of Venkatasubban (59) include studies on the cytology of *Phoenix*.

BREEDING BACKGROUND

The genetic behavior of the date palm is little known. Seedling populations of certain varieties tend to resemble the female parent in vegetative and fruit characters (Appendix 1). This feature has been useful in selecting for further hybridization backcrossed (BC) males with growth characters resembling those of the female parent. Fruit characters carried by male palms are unknown, but a study of female progeny in BC populations may suggest which fruit characters are being transmitted and the degree of character homozygosity.

Subtleties of leaf color, angle of pinnae, arrangement of rachis spines and other vegetative characters have not been evaluated in progeny to establish a precise degree of resemblance to the female parent. However, increased numbers of individuals in each successive BC generation show the characters of the recurrent female parent. As advanced BC males become available, it should be possible to study the inheritance of characters in progeny derived from parents with distinctive attributes.

The literature reviewed by Osman, et al., (46) on xenia and metaxenia clearly demonstrates that in the date palm, the pollen parent may strongly influence fruit

size, seed size, and time and uniformity of ripening. If such results can be achieved with the relatively few selected males that have been studied, the range and influence of metaxenia should be subject to substantial improvement through breeding and selection.

First consideration should be given to breeding, testing and selection of males within *P. dactylifera*, if high quality fruit and high yields are desired. Preliminary data (40) on the metaxenic effect on dates of pollen from related species indicate that pollen of *P. sylvestris* behaves much like that of *P. dactylifera*. Pollen of *P. reclinata*, *P. canariensis*, *P. roebelenii*, *P. rupicola*, and a putative hybrid *P. rupicola* X *P. reclinata*, all had metaxenic effects on Deglet Noor fruit, some of which were unfavorable. Nixon suggested that pollen of some of the species that induced late ripening might be useful under conditions where early ripening would be a disadvantage. H. C. Barrett, (unpublished data), successfully hybridized date varieties with *P. humilis*; fruits were fairly normal, but a xenic effect occurred in seeds, many of which were small and very slender.

BREEDING OBJECTIVES

Interspecific hybridization in *Phoenix*, while of interest taxonomically and horticulturally, should not be expected to improve commercial fruit quality. The most that such crosses could accomplish would be to extend the range of date-like fruits. Interspecific hybridization might be used in a long-term date breeding program to modify growth habit, especially by inducing moderate to slow vertical growth.

Breeding within *P. dactylifera*, a remarkably diverse species in fruit and vegetative characters and adaptation to a wide range of environments, offers the best route for developing varieties with desirable fruit quality, yield, and growth habit. Early attempts to breed superior female varieties in which ordinary males were used had little chance of success because the species is dioecious and heterozygous. Sibling crosses were not much better. In 1948, Nixon and Furr (45) began the first breeding program to develop BC males that would hypothetically approach the recurrent female variety in

genetic constitution and that could be expected to transmit some maternal characters.

The primary goal of date breeding is to achieve the highest fruit quality and yield consistent with local requirements. The latter might include:

(a) Tolerance or resistance to cold, extreme heat, high humidity, rain damage, insect attacks, physiological and fungal diseases, saline water, marginal soils and poor drainage.

(b) Adaptation to mechanical harvesting, processing and pest control.

(c) Modification of growth habit to reduce the rate of vertical growth, reduce the number and size of leaf spines, increase the length and flexibility of fruit stalks, improve distribution and numbers of fruits per bunch to increase fruit size and reduce thinning operations.

(d) Modification of fruit quality, seed size, uniformity of ripening and time of ripening, and reduction of skin separation in fruit of soft varieties.

(e) Development of male palms with metaxenic characters that could be used to manipulate fruit production.

(f) Development of inbred lines to produce seed with sufficiently uniform characters to permit propagation of palms from seed.

Breeding of date varieties for production of refined sugar might be feasible because sugar is the principal constituent of date fruit. Dried, ground date pulp and date syrup are commonly used as sugar substitutes. We have received inquiries from international consulting firms concerning dates as a source of refined sugar, but apparently no processing is underway, other than the production in Iraq of a clear, liquid date sugar syrup.

Based on yield, sugar content and trees/ha, in California dates might produce more than 10 metric tons/ha of sugar. Cook and Furr (12) found a range of 68 to 85% total sugars, based on dry weight of pulp, among 51 cultivars that included most of the principal Old World date varieties. Micheli (31) reported a range of 65 to 86% total sugar among 77 Libyan varieties; Hussein (24) gives a sugar content of 72 to 82% for 13 Egyptian date varieties. Yields of 17 date varieties under California conditions (44) vary from 45 to 55 kg/tree for 'Khadrawy,' with

sugar content of 80.5% (12), to 136 kg/tree for 'Barhee' with a sugar content of 83.9%. 'Deglet Noor' and 'Zahidi,' easily handled semi-dry varieties, yield 91 to 136 kg/tree and have a sugar content of 77% and 78% respectively.

A remote goal, suggested by the occurrence of a few individual trees that bear polygamous or perfect flowers, is to breed date palms with this flowering habit well enough developed to obviate the need for artificial pollination.

The wild date palm, or date-sugar palm, *P. sylvestris*, is the second species of substantial economic importance in this genus. This palm is adapted to a wide range of environments and might be improved by breeding and selection (1). The wild date palm has long been the basis of a semi-refined sugar and syrup industry in India and elsewhere in Southeastern Asia (1, 2, 25, 38, 60). The yield of partially refined sugar as gur or jaggery is perhaps 5 metric tons/ha. Joshi and Gopinathan (25) estimated the plantings of this palm in India at 13,500 ha in 1952; Davis' (15) estimate of 30,000,000 wild palms in India, of which 20,000,000 should be tappable, markedly increases the potential acreage. Sugar production data for coconut (*cocos nucifera* L.), palmyra (*Borassus flabelliformis* Murr. [= *B. flabellifer* L.]) and sago (*Caryota urens* L.) are given by Joshi and Gopinathan (25) and [Naik], (38).

BREEDING IN MOROCCO

Breeding for resistance to fusariose is a major date palm project in Morocco. Pereau-Leroy (48) showed that certain varieties were tolerant or resistant to the disease. His work was terminated, but investigations on bayoud disease were resumed in the early 1960's (27, 28, 29, 58). The resistant varieties (48) were recovered and many new, resistant male and female selections were identified in field plantings. Toutain and Louvet (58) listed the following varieties as resistant: 'Bou Stammi Noire,' 'Bou Feggous ou Moussa,' 'Iklane,' 'Sair Layalet,' 'Tadment,' and 'Takerboucht.' 'Sair Layalet' has the best quality (27); the other varieties have only good to mediocre fruit quality. 'Outoukdime,' though of high quality, is no longer rated among the most resistant varieties. Some of these varieties are used in

domestic commerce and in oasis rehabilitation but they do not replace 'Medjool,' 'Bou Feggous,' and other varieties which once provided fruit for export to European markets.

Since 1973, pollen of advanced BC "varietal" male palms from the Indio Station has been supplied to G. Toutain for pollination of fusariose-resistant females in an attempt to breed varieties with high quality, yield, and disease-resistance. Nearly 100,000 hybrid seeds were produced in Morocco from 1972 to 1974, including hybrids of fusariose-resistant Moroccan female palms with BC male parents, hybrids between Moroccan female and male lines resistant to fusariose, and other classes of hybrids (54, 55, 56, 57). Seedling progeny of advanced BC males from Indio are growing in disease trials at Zagora, in an effort to select fusariose-resistant "varietal" males.

BREEDING IN CALIFORNIA

Background:

Deglet Noor is grown on more than 80% of the California date acreage. The fruit of this high quality, semi-dry, Algerian variety is adapted to mechanical harvesting and processing and can be expected to dominate the U. S. market for a long time. The semi-dry fruit of the high-yielding Zahidi variety, though inferior in quality to that of Deglet Noor, can be handled mechanically. The soft-fruited varieties, Medjool, Barhee, Khadrawy, 'Halawy' and others require manual harvesting and processing. Fruit of these varieties is handled principally through local retail and mail order outlets. Medjool, because of its large size and attractive appearance, is being processed by two of the large date firms because returns compensate for the extra labor required in handling.

The date breeding program of the Agricultural Research Service is aimed primarily at developing female varieties with: (a) quality and yield equal to, or superior to, those of Deglet Noor, (b) freedom from black nose, a serious physiological disorder of ripening Deglet Noor fruit, (c) adaptation to mechanical harvesting and processing, (d) retention of the long fruit stalk of Deglet Noor that facilitates handling of fruit bunches, and (e) a moderate rate of vertical growth.

Among soft varieties, the main object is to combine the quality and yield of Medjool with long fruit stalks to facilitate handling of bunches. Selection of other soft-fruited dates with outstanding size, quality, and yield, or some other useful character, will be made as such seedlings appear among progeny.

Initially, 35 varieties represented by 48 breeding lines were included in Nixon and Furr's (45) BC program; these have been reduced to 14 varieties represented by 22 lines, as a result of genetic weakness in some lines and changes in breeding objectives. Several lines have advanced to the fourth and fifth generation backcross. (Table 2).

Progeny from the third BC of Barhee include many females that have had fruit which closely resembles that of the female parent. This is in line with Nixon and Furr's (45) evaluation of Barhee progeny. Varietal similarity exists among the fruit of BC progeny in Medjool and Khadrawy, which have large and small fruit, respectively. Deglet Noor backcrosses have been disappointing because none of the females from the fourth BC has fruit similar to that of Deglet Noor.

INTERVARIETAL CROSSES

The term "intervarietal crosses" (51) is a convenient way of referring to crosses between female varieties and BC males. The early crosses reported by Nixon and Furr (45) yielded only a few hybrids worth keeping. Progeny of two crosses of 'Abbada' X Medjool BC₂ (two male lines) gave distinctly different fruit; female seedlings of one line had small-to-medium sized blackish, dry fruit and those of the second line had blackish, large fruit as soft as that of Medjool.

Many advanced BC males flowered in 1970 and 1971; 62 intervariatal crosses were made. The female varieties used were described briefly by Barrett (3), Appendix 2. From 1971 to 1974, about 3,000 hybrid seedlings were planted, of which more than 1,200 female palms should become available for evaluation. Detailed genetic studies cannot be made on the large number of small populations, but fruit and growth characters observed in these progeny should help in planning future breeding work.

Progeny of the 1970 crosses have progressed well. In 1975, 159 females, or 37%

of the total population, fruited and many plants will be evaluated for the second time. Large numbers of unsatisfactory females were removed in 1974.

Among 1971 progeny field-planted in 1972, nearly 400 female palms fruited in 1975; these represent 25% of the total progeny and are hypothetically equivalent to about 50% of the females.

The parentage and data on flowering and fruiting in 1975 of progeny of 36 crosses made in 1971 are given in Table 3. The crosses are arranged by female parent and in descending order of flowering. Among a total of 1,183 seedlings, 311 females and 502 males flowered; the overall percentage of flowering (69%) represents good performance for plants less than 4 years old from seed. The limited data suggest that 'Empress' Khadrawy, and 'Thoori' as female parents, and Khadrawy BC₃, 'Tadala' BC₁, and Thoori BC₃ as male parents, may induce early flowering in a high proportion of the crosses in which they occur.

FUTURE PLAN

The plan at Indio is to: (a) advance promising BC male lines to the fifth generation, (b) make intervarietal hybrids, (c) test promising hybrid female progeny as potential new varieties, (d) select and test males with valuable metaxenic characters, (e) make sibling and line crosses among BC lines, (f) make exploratory interspecific hybrids.

SEED AND PLANT COLLECTIONS

Date seed may be held in common storage at moderate temperatures for at least 5 or 6 years with almost no loss in germinability; longer storage results in a gradual loss of vitality (43). This enables the breeder to make crosses during a favorable season and store seed until it can be used. We accumulate and store seed of desired crosses and varieties so that we can plant new material as land becomes available and also distribute seed to cooperators.

California enjoys a unique advantage in that the most damaging pests and diseases of the date palm are absent. Offshoots, seed, and pollen may be distributed to most countries without the hazard of introducing a serious pest. Consequently, Indio is a good place for a

date palm germplasm repository. The Station collection consists of (a) 30 named varieties (another 10 or more foreign and local varieties are available from growers), (b) BC males, the numbers of which will be expanded as more advanced BC generations are produced, (c) current plantings of intervarietal crosses that provide female selections for evaluation and direct use, or for further breeding; and (d) male palms with valuable metaxenic characters.

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J. R. Furr and R. W. Nixon, Collaborators (formerly Research Horticulturists) and R. L. Bergman, Agricultural Research Technician, U. S. Date and Citrus Station, Indio, California; H. C. Barrett, Research Horticulturist, U. S. Horticultural Research Laboratory, Orlando, Florida; Myron Kinnach, Curator and Superintendent, and F. C. Boutin, Botanist, The Huntington Botanical Gardens, San Marino, California; L. C. Hurt, Foreign Agricultural Service, U. S. Department of Agriculture, Washington, D. C.; the Librarians, Bio-Agricultural Library, University of California, Riverside, California; J. Ratafs and H. Gilbert, National Agricultural Library, Beltsville, Maryland.

LITERATURE CITED

1. Annet, H. E., G. K. Lele, and M. A. Bhailal. 1913. The date sugar industry in Bengal, an investigation into its chemistry and agriculture. Mem. Dep. Agric. India, Chem. Ser. 2: 281-389.
2. Annett, H. E., G. B. Pal, and I. B. Chatterjee. 1918. Experiments on the improvement of the date palm sugar industry in Bengal. Mem. Dep. Agric. India, Chem. Ser. 5:69-116.
3. Barrett, H. C. 1973. Date breeding and improvement in North America. Fruit Var. J. 27:50-55.
4. Barreveld, W. H. 1971. Industrial use of second quality dates. World Crops 23:209-210.
5. Beal, J. M. 1937. Cytological studies

in the genus *Phoenix*. Bot. Gaz. 99:400-407.

6. Beccari, O. 1890. Revista monografica delle specie del genere *Phoenix* Linn., 3(5):345-429. In *Malesia, raccolta di osservazioni botaniche intorno alle piante dell'Arcipelago Indo-Malese e Papuano*. Fratelli Benicini, Rome.
7. Burkhill, I. H. 1935. *Phoenix*, 2: 1712-1714. In *A dictionary of the economic products of the Malay Peninsula*, Crown Agents for the Colonies, London.
8. Candolle, A. De. 1886. Origin of cultivated plants. 2nd ed. Kegan Paul, Trench and Co., London 468 p.
9. Carpenter, J. B. 1972. Date varieties potentially useful in Algeria and prospects for a date breeding program, p. 213-216. In A. G. Watson, et al., [ed.] *Proc. First Intl. Seminar and Workshop on Bayoud, Algiers*, October 1972. Inst. Tech. Agric. Saharienne, Algiers. 263 p.
10. Chevalier, A. 1932. Principales cultures et produits vegetaux du Sahara. Rev. Bot. Appl. Agric. Trop. 12: 711-736.
11. Chevalier, A. 1952. Recherches sur les *Phoenix* africains. Rev. Intl. Bot. Appl. 32:205-236.
12. Cook, J.A., and J. R. Furr. 1953. Kinds and relative amounts of sugar and their relation to texture in some American-grown date varieties. Proc. Amer. Soc. Hort. Sci. 61:286-292.
13. Danthine, H. 1937. Le palmier-dattier et les arbres sacres dans l'iconographie de l'Asie occidentale ancienne. 2 Vol. Librairie Orientaliste, Paul Geuthner. Paris.
14. Darlington, C.D., and A. P. Wylie. 1956. Chromosome atlas of flowering plants. George Allen & Unwin Ltd., London. 398 p.
15. Davis, T. A. 1972. Tapping the wild

- date. *Principes* 16:12-15.
16. Direction de la Recherche Agronomique, Maroc, et l'Institut National de la Recherche Agronomique, France. 1972. Le palmier dattier et sa fusariose vasculaire. H. Faraj and J. M. Soupault [ed.]. 179 p. A collection of 12 papers by various authors, 1963-1972.
 17. Doulat, E. 1944. La structure du noyau et des chromosomes somatiques chez le *Phoenix dactylifera* L. *Rev. Cytol. Biol. Veg.* 7:14-23.
 18. Dowson, V. H. W. 1968. The present condition of world date culture. *Date Growers' Inst. Rep.* 45:14-18.
 19. Dowson, V. H. W., and A. Aten. 1962. Dates — handling, processing and packing. *FAO Agric. Develop. Paper* 72, Food Agric. Organ. U. N., Rome. 329 p.
 20. Elmer, H. S., J. B. Carpenter, and L. J. Klotz. 1968. Pests and diseases of the date palm. *FAO (Food Agric. Organ., U. N.) Plant Protect. Bull.* 16:77-91, 97-110.
 21. Food and Agriculture Organization of the United Nations. 1972. *Production yearbook*, p. 148. *FAO/UN*, Rome, Italy.
 22. Goor, A. 1967. The history of the date through the ages in the Holy Land. *Econ. Bot.* 21:320-340.
 23. Hussain, A. A. 1974. Date palms and dates with their pests in Iraq. *Univ. Baghdad, Min. Higher Educ. Sci. Res. Baghdad*, 166 p.
 24. Hussein, F. 1972. Kinds and relative amounts of sugar in some Egyptian date cultivars. *Beitr. Trop. Subtrop. Landwirt. Tropenveterinaermedizin* 10:159-162.
 25. Joshi, B. C., and N. Gopinathan. 1956. Sugar yielding palms as a potential source of sugar supply. 9th Cong. Int. Soc. Sugar Cane Tech. 1956:1-10.
 26. Lavielle, E. 1970. Principes et methodes de selection de palmiers resistants aux maladies fongiques. *Al Awamia* 35:123-127.
 27. Louvet, J., J. Bulit, G. Toutain, and P. Rieuf. 1970. Le bayoud, fusariose vasculaire de palmier dattier, symptomes et nature de la moyens de lutte. *Al Awamia* 35:161-181.
 28. Louvet, J., and G. Toutain. 1972. Recherches sur les fusarioses. X. — Nouvelles observations sur la fusariose du palmier dattier et precisions concernant la lutte, p. 154-176. *In* H. Faraj and J. M. Soupault [ed.] *Le palmier dattier et sa fusariose vasculaire*. *Dir. Rech. Agron., Maroc & Inst. Nat. Rech. Agron., France*. Rabat and Paris.
 29. Louvet, J., and G. Toutain. 1973. Recherches sur les fusarioses. VIII — Nouvelles observations sur la fusariose du palmier dattier et precisions concernant la lutte. *Ann. Phytopathol.* 5 (1):35-52.
 30. Martius, C. F. P., De. 1836-1850. *Phoenicinae*, 3:257-276, 320-321. *In* *Historia naturalis palmarum: expositio systematica*, F. Fleischer, Leipzig.
 31. Micheli, A. 1936. Considerazioni sulla coltivazione della palma da datteri nelle oasi di Gialo, Augila, Gicherra e Marada e proposte per un miglioramento della coltura. *L'Agric. Colon.* 30:417-427.
 32. Miller, W., J. G. Smith, and N. Taylor. 1930. *Phoenix*, 3:2591-2594. *In* L. H. Bailey [ed.] *The standard cyclopedia of horticulture*, The Macmillan Co., New York.
 33. Moore, H. E., Jr. 1963. An annotated checklist of cultivated palms. *Principes* 7:119-182.
 34. Moore, H. E., Jr. 1973. The major groups of palms and their distribution. *Gentes Herb.* 11:27-140.
 35. Mowry, H. 1952. Native and exotic palms of Florida. (Revised by R. D. Dickey and E. West.) *Univ. Fla. Bull.* 152. 70 p.
 36. Munier, P. 1973. Le palmier-dattier. G. P. Maisonneuve & Larose, Paris. 221 p.
 37. Munier, P. 1974. Le probleme de l'origine du palmier-dattier et l'Atlantide. *Frûits* 29:235-240.
 38. [Naik, G.] 1958. *Tad gud parichaya*. Ed. 2. Kahdi and Village Industries Commission, Kishorilal Lalji Ganatra, Trend Printers, Girgaum, Bombay. 154 p. [Text in English.]
 39. Nemec, B. 1910. *Das Problem der Befruchtungsvorgange und andere Zytologische Fragen*. Gebruder Born-Traeger, Berlin. 235 p.
 40. Nixon, R. W. 1936. Metaxenia and interspecific pollinations in *Phoenix*. *Proc. Amer. Soc. Hort. Sci.* 33: 21-26.
 41. Nixon, R. W. 1951. The date palm — "tree of life" in the subtropical deserts. *Econ. Bot.* 5:274-301.
 42. Nixon, R. W. 1959. Pollination, breeding and selection of date palms, p. 22-41. *In* R. W. Nixon [ed.] *First FAO (Food Agric. Organ., U. N.) Intl. Tech. Meeting Date Production Processing*, Tripoli, Libya, 5-11 Dec., 1959. *Meeting Rep. PL/4*, FAO, Rome.
 43. Nixon, R. W. 1964. Viability of date seeds in relation to age. *Date Growers' Inst. Rep.* 41:3-4.
 44. Nixon, R. W. 1969. Growing dates in the United States. *U. S. Dep. Agric., Agric. Inform. Bull.* 207. 56 p.
 45. Nixon, R. W., and J. R. Furr. 1965. Problems and progress in date breeding. *Date Growers' Inst. Rep.* 42:2-5.
 46. Osman, A. M. A., W. Reuther, and L. C. Erickson. 1974. Xenia and metaxenia studies in the date palm *Phoenix dactylifera* L. *Date Growers'*

- Inst. Rep. 51:6-16.
47. Oudejans, J. H. M. 1969. Date palm, *Phoenix dactylifera* L., p. 243-257. *In* Ferwerda, F. P. and Wit, F. [ed.] Outlines of perennial crop breeding in the tropics, H. Beenman & Zonen, N. V., Wageningen, The Netherlands.
 48. Pereau-Leroy, P. 1958. Le palmier dattier au Maroc. Inst. Français Rech. Fruit. Outre-Mer, Paris and Min. Agric., Serv. Rech, Agron., Rabat, Morocco. 142 p.
 49. Popenoe, P. 1914. Origin of the date palm. *J. Hered.* 5:498-508.
 50. Popenoe, P. 1973. The date palm. Henry Field [ed.] Field Research Projects, Coconut Grove, Miami, Florida. 247 p.
 51. Ream, C. L. 1975. Date palm breeding — a progress report. Accepted for publication, Date Growers' Inst. Rep.
 52. Reuveni, O. 1969. Date palm, p. 143-180. *In* Div. Subtrop. Hort., Volcani Inst. Agri. Res. 1960-1969, Bet Dagan, Israel.
 53. Toutain, G. 1967. Le palmier dattier, culture et production. *Al Awamia* 25:83-151.
 54. Toutain, G. 1972. Rapport annuel d'activités années 1971-1972. Sta. Cent. Rech. Palmier Dattier, Dir. Rech. Agron. Min. Agric. and Reforme Agraire, Marrakech, Morocco.
 55. Toutain, G. 1973. Rapport annuel d'activités 1972-1973. Sta. Cent. Rech. Palmier Dattier, Dir. Rech. Agron. Min. Agric. and Reforme Agraire, Marrakech, Morocco.
 56. Toutain, G. 1974. Rapport annuel d'activités 1973-1974. Sta. Cent. Agron. Saharienne, Dir. Rech. Agron. Min. Agric. and Reforme Agraire, Marrakech, Morocco.
 57. Toutain, G. 1975. Rapport annuel d'activités 1974-1975. Sta. Cent. Agron. Saharienne, Dir. Rech. Agron., Min. Agric. and Reforme Agraire, Marrakech, Morocco.
 58. Toutain, G., and J. Louvet. 1972. Resistance au bayoud dans les variétés de palmier dattier, p. 177-179. *In* H. Faraj and J. M. Soupault [ed.] Le palmier dattier et sa fusariose vasculaire. Dir. Rech. Agron., Maroc and Inst. Nat. Rech. Agron. France. Rabat and Paris.
 59. Venkatasubban, K. R. 1945. Cytological studies in palmae. Part I. Chromosome numbers in a few species of palms of British India and Ceylon. *Proc. Indian Acad. Sci., Sec. B*, 22:193-207.
 60. Watt, G. 1892. Phoenix, 6(1): 199-215. *In* A dictionary of the economic products of India. W. H. Allen & Co., London.

Table 1. Species of Phoenix recognized by several investigators, with year of publication and the literature citation

Species	Martius 1836— 1850 (30)	Beccari 1890 (6)	Miller et. al 1930 (32)	Chevalier 1932, 1952 (10, 11)	Mowry 1952 (35)	Moore 1963 (33)	Munier 1973, 1974 (36, 37)
<i>abyssinica</i> Drude						+	
<i>acaulis</i> Buch. — Ham. ex Roxb.*	+	+	+	+	+	+	+
<i>atalantica</i> A. Chev.				+			+
<i>canariensis</i> Hort. ex Chab.*		+	+	+	+	+	+
<i>dactylifera</i> L.*	+	+	+	+	+	+	+
<i>farinifera</i> Roxb.	+	+		+		+	+
<i>hanceana</i> Naudin				+			+
<i>humilis</i> Royle		+	+	+	+		+
<i>loureirii</i> Kunth	+				+	+	
<i>ouseleyana</i> Griff.	+						
<i>paludosa</i> Roxb.*	+	+	+	+	+	+	+
<i>pumila</i> Hort.			+				
<i>pusilla</i> J. Gaertn.	+	+	+		+	+	
<i>reclinata</i> Jacq.*	+	+	+	+	+	+	+
<i>roebelenii</i> O'Brien			+	+		+	+
<i>rupicola</i> T. Anderson*		+	+	+	+	+	+
<i>spinosa</i> F.C. Schum	+						
<i>sylvestris</i> (L.) Roxb.*	+	+	+	+	+	+	+
<i>zeylanica</i> Trimen			+		+		

* Species recognized by Beccari and subsequent investigators listed.

Table 2. Variety, line number and backcross generation of male palms at the U.S. Date and Citrus Station, Indio, California, 1975

Variety	Line No.	Backcross generation
Amir Hajj	3	3
Amir Hajj	48	1
Barhee	5	3
Barhee	6	4
Barhee	49	3
Dayri	7	3
Deglet Beida	9	1
Deglet Noor	10	5
Empress	—	1
Halawy	13	3
Halawy	14	4
Khadrawy	20	4
Khadrawy	21	4
Khalasa	22	2
Medjool	30	4
Medjool	31	5
Medjool	32	3
Medjool	33	3
Tadala	40	1
Tazizoot	41	1
Thoory	42	4
Zahidi	43	2

Table 3. Flowering and fruiting in 1975 of progeny of 36 date crosses planted in 1972^a

Cross	Date palm seedlings		
	Total (no.)	Flowering ^b (%)	Fruiting (%)
Female X Backcrossed (BC) Male			
Badrayah X Deglet Noor BC ₄	30	73	30
Dayri X Thoory BC ₃	36	86	11
X Tadala BC ₁	36	69	28
X Deglet Noor BC ₄	36	53	8
X Khadrawy BC ₃	36	50	11
X Medjool BC ₃	32	41	3
Deglet Beida X Dayri BC ₂	35	71	20
X Deglet Noor BC ₄	34	62	24
X Medjool BC ₃	34	44	24
Deglet Noor X Khadrawy BC ₃	32	78	31
X Tadala BC ₁	34	62	21
X Thoory BC ₃	35	54	9
X Dayri BC ₂	32	28	9
Deglet Noor BC ₃ X Khadrawy BC ₃	35	94	43
X Tadala BC ₁	34	82	44
X DN BC ₄	27	78	22
X Dayri BC ₂	36	47	25
Empress X Khadrawy BC ₃	27	96	44
X Tadala BC ₁	34	91	13
X Dayri BC ₂	31	84	35
X Deglet Noor BC ₄	36	67	22
X Medjool BC ₃	30	63	27
Khadrawy X Thoory BC ₃	32	84	31
X Dayri BC ₂	25	76	44
X Tadala BC ₁	32	72	25
Kush Zebda X Thoory BC ₃	31	90	23
X Tadala BC ₁	31	77	39
X Dayri BC ₂	28	57	11
Medjool X Thoory BC ₃	35	83	34
X Tadala BC ₁	35	74	31
X Dayri BC ₂	34	24	9
Thoory X Khadrawy BC ₃	33	91	39
X Medjool BC ₃	35	77	31
X Deglet Noor BC ₄	33	73	45
X Tadala BC ₁	34	70	35
X Halawy BC ₃	33	61	15

^a Seed was planted in a glasshouse in December 1971. Seedlings were transplanted to field plots June 1972.

^b Male and female.

Appendix 1. Ratings of date seedling progenies for resemblance to the female parent, (See footnote). Reproduced from Nixon and Furr (1965) with the authors' permission

Rating	Female parent	Line (L) or accession number	Generation	Number of seedlings
2.7	Barhee	55-102	BC 1	23
2.7	Barhee	55-103	BC 1	24
2.4	Medjool	L-31	BC 2	39
2.4	Menakher	L-34	BC 1	22
2.3	Thoory	L-42	BC 2	40
2.3	Medjool	L-30	BC 2	27
2.2	Medjool	L-33	BC 1	26
2.2	Medjool	58-380	BC 1	23
2.2	Dayri	L-7	BC 1	39
2.1	Khadrawy	L-20	BC 2	22
2.1	Amir Hajj	58-381	F1	30
2.1	Ammary	58-382	BC 1	18
2.0	Barhee	L-6	BC 2	23
2.0	Kustawy	L-27	BC 1	42
2.0	Hayany	L-15	BC 1	26
1.9	Zahidi	L-44	BC 1	29
1.9	Deglet Noor	L-11	BC 3	37
1.9	Halawy	L-14	BC 1	39
1.8	Rhars	L-36	BC 1	24
1.8	Khir	L-23	BC 1	24
1.8	Khalasa	59-234	F1	25
1.8	Koroch	L-24	BC 1	13
1.7	Amir Hajj	L-3	BC 1	27
1.5	Saidy	L-46	BC 2	19
1.1	Khadrawy	L-21	BC 2	24

"All palms that were large enough were rated for overall resemblance of vegetative characters to the female parent according to the following: little or no resemblance — 1, moderate resemblance — 2, strong resemblance — 3. The sum of the ratings of all the progeny of a given lot or line divided by the total number of individuals provided an average rating for that group of palms Of 25 lots representing 18 varieties, average variety resemblance ratings ranged from 2.7 to 1.1 and 15 were 2.0 or above, indicating definite resemblance to the female parent."

Appendix 2. Source of some desirable characters used in the date-breeding program. Reproduced from Barrett (1973), with the author's permission

<u>Variety</u>	<u>Desirable Characters</u>
Abbada	Attractiveness, glossy black fruit with frost-like bloom, midseason maturity.
Amir Hajj	High quality, little spoilage of fruit in wet weather.
Barhee	High quality, heavy yield, late maturity, low tannin in khalal stage.
Bedraya	Large fruit, firm texture, midseason maturity.
Dayri	High quality, distinctive rich flavor, moisture tolerance, good size, semidry texture.
Deglet Beida	Light-colored fruit, smooth skin, very firm texture, early maturity.
Deglet Noor	Superior quality, distinctive rich flavor, semidry texture, long fruitstalks.
Empress	High quality, attractiveness, good size, distinctive rich flavor.
Halawy	High quality, distinctive rich flavor, moisture tolerance, early maturity.
Horra	Good size, very firm texture, long fruitstalks, midseason maturity.
Khadrawy	High quality, dwarf stature, moisture tolerance, precocious flowering, sparse spines, early maturity.
Kush Zebda	Superior fruit quality, distinctive rich flavor, long fruitstalks.
Medjool	Large fruit, moisture tolerance, early maturity, good quality.
Tadala	Large fruit, moderate moisture tolerance, attractiveness, early maturity.
Thoory	Light-colored fruit, moderately large fruit, very firm, moisture tolerance, late maturity.

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